F.I.A.F. Technical Commission

FILM PRESERVATION

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PRESERVACIÓN CINEMATOGRÁFICA / FILM PRESERVATION

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TABLE OF CONTENTS

PRESENTATION

During the meeting of the Commission for Preservation, which took place in London as part of the FIAF Congress in 2000, Michael Friend, President of the Commission, proposed a study to be carried out. This study would collect and bring up to date the experiences of the publications produced by our International Federation of Film Archives (FIAF), paying attention to the changes that are taking place in cinematographic technology during the last decade of the 20th century as well as to the development of knowledge relating to preservation.

For this study we had to start from the analysis of two very important publications issued by the previous commissions for preservation: Preservation and Restoration of Moving Images and Sound, edited in English in 1986. Some of the most distinguished names in cinematographic conservationism, Harold Brown, Herbert Volkmann, Hans-Eckart Karnstädt, Hubertus Pietrzok, and others contributed to this publication, and Preservation of Moving Images and Sound, written by Hening Schou, then President of the Commission of Preservation, edited in English and French by FIAF, in 1990, and in Spanish by the General Direction of Cinematographic Activities of UNAM, Mexico, in 1992.

The study of these two publications makes it clear, firstly, that both contain fundamental contributions to cinematographic preservation, which continue to maintain their value.

Simultaneously, both works represent very different working methodologies; in the first one, each author carried out one or more of the themes discussed in the work; while, in the second, all work was unified by the Henning Schou's staff. Since both methodologies are equally valid, we can say that the first one allows the study of each theme in depth and that the second offers clearer explanations, which is a considerable aim in a work of this kind.

On the other hand, the development in knowledge and even in the general ideas on cinematographic preservation and restoration make the realization of a new general approach to these problems necessary – in the style of those realized in the reference works.

In following meetings, the Technical Commission of Preservation adopted a basic outline for this project.

A new work would be written, dedicated to the study of problems of conservation of cinematographic heritage in times of technological changes, and divided into three sections: Inspection and classification of materials for preservation; manipulation and reproduction of the materials and design and construction of storage installations.

After the Congress of Rabat, in 2001, the Technical Commission headed by Joâo Sócrates de Oliveira, began the preparation of the work, written in a unitary way and submitted to revision of the Technical Commission.

The difficulties that logically appeared during its development obliged the introduction of modifications to the initial outline.

From the beginning, the manipulation and reproduction of the materials were considered as a whole, but the continuous changes in the technologies of reproduction led to the consideration of these two aspects as the subject of independent studies.

In this way, this work is focused on the knowledge of the physical, chemical and functional characteristics of the materials used in the reproduction of moving images and sound, in the elaboration of criteria for their classification and in the study of their conditions of preservation.

In writing this work we didn't intend to collect all the questions related to the preservation of the cinematography – it would be an impossible objective – but instead to prepare an aid for the archivists in their difficult job of elaborating and classifying the criteria of conduct.
We hope to have achieved something of this goal.

Alfonso del Amo García
Head of the Technical Commission of FIAF
April 2004

INTRODUCTION

It is not possible for a cultural archive to put time limits on the preservation of the works it holds, since the aging is an inevitable process that affects all the materials, altering their functional characteristics and imposing limits on their possibilities for preservation. Cinematographic films are included among these materials that show greater predisposition to aging.

Reproduce to preserve

Simultaneously with the inevitable aging of its materials, the fact that the cinematography works on a succession of duplicates can act as relief from the rapid aging of its materials and systems.

Somehow, reproducing the data contained in the original bases on a new material base, the aging meter does situate at the beginning again and, for that, reproduce to preserve is a basic strategy in the activity of the cinematographic archives, but this strategy also presents a lot of difficulties, is economically expensive and it can lead to important damage to the original works.

Cinematography functions with duplicates and reproducing the films to preserve their use, is not an activity invented by the archives. Almost from the first years of cinematography, the industry discovered that the quantity of good quality prints that can be obtained from its original negative is very limited, and the industrial system of duplication, the development of which would conclude in the 1920’s, was an answer to the imperative necessity of prolonging the useful life of the cinematographic originals.

In the archives, the preservation duplicates began to transfer the cinematographic works to security bases and they have become progressively more complex according to the increase in the damages in the originals.

For many years now, the films printed on inflammable bases are reproduced on security films; for many archives, the production of these duplicates is an immense task, which consumes a large part of its resources and will still take years to conclude.

On the other hand, as the archives would immediately discover, due to the limits of its systems and of the materials available for the production of the duplicates – and to the continuous economic short- fallings – in many of these duplicates the characteristics of the original registries have not been correctly preserved and have even been seriously altered, manipulated or destroyed.

At present, the reproduction of the collections is turning into an inescapable necessity.

The technical change that is developing in cinematography will produce – is producing – a critical situation for the preservation of the films. All the techniques of production and distribution used by cinematography are evolving into electronic imaging systems, and the archives, in order to maintain the access to the works they preserve, have to think about the production of duplicates suitable for exhibition in the electronic medium.

But, if what we try to achieve is to preserve the cinematographic works, the mass reproduction of collections on an electronic image support presents as yet irresolvable problems.

- The reproduction of the collections on electronic supports adequate for the preservation of all the data contained in the photochemical films (in other words, on data supports of high density of storage) could only be carried out having several years, a great quantity of human and technical resources, and enormous economic budgets.
The electronic imaging systems are continually changing and it is impossible to know what will be the characteristics, in the future, of those which manage to become consolidated as a standard of quality for cinematography; it is probable that we will have to consider the coexistence of various professional standards of quality and that the films have to spread through all them.

Apart from those which will be the standards of quality consolidated by electronic cinematography, the image characteristics of these registers are clearly different from the photochemical cinema characteristics.

If the criteria used in the production of duplicates and restorations with photochemical media can, on many occasions, be described as adaptations to the reigning aesthetic taste at the time of reproduction, the differences objectively existent between the electronic and photochemical image systems, can contribute to seriously intensify these types of manipulations.

- Even if reproduce-to-preserve be a consubstantial practice in the cinematography, the archives cannot accept preservation duplicates that don't preserve all the characteristics of the works and, whatever may be the technical base used for the duplicate, a correctly made preservation duplicate – a duplicate able to preserve all the characteristics of the images and sounds contained in the original registers – will represent a technical effort equivalent to a restoration.

In the archives, the reproductions for preservation have to be planned and developed heeding selective criteria and the cultural preservation of the cinematographic collections cannot be planned – neither technically nor economically – through massive reproduction policies.

In these conditions, it is absolutely necessary to develop systems capable of analysing the photographic and sound characteristics of each film and to transmit these data further over the degradation of the materials (and it is advisable to remember that presently we already preserve thousands of damaged films), until they can be used by the technicians responsible of the preservation of the reproducibility of the films in the future.

On the other hand, because of the lack of conservation characteristics of the present electronic image bases and the non-existence of established standards, the reproductions produced on electronic supports, shall have to be repeated within a few years on other systems and bases.

This problem, familiar to television archives, is especially serious for the preservation of the movies filmed with electronic media, and they shall have to be reproduced over and over again to save them from equipment obsolescence and functional decay of tapes and discs.

The mass reproduction of the photochemical collections on electronic image bases can be a necessary activity to facilitate the access to the movies but, with the available media actually, this kind of mass reproduction doesn't constitute, on its own, a method for the preservation of the works.

Preserve to protect

To preserve the original registers, in the best functional conditions and for the longest time possible, is the only policy that can assure the survival of the cultural heritage until, due to the development of the bases and systems, suitable for resisting the passage of time and capable of collecting all the data of the original characteristics, and the consolidations of standards accepted all over the world for the electronic image registers, it may be possible to appropriately plan the transfer of the photochemical collections to electronic bases.

The preservation of the original bases is only possible if we have at our disposal the appropriate installations and systems for the preservation and the handling of each type of material.

The availability of the appropriate warehouses is an indispensable condition, but until now it has not been possible (and it may never be) to elaborate a single criterion as to what these warehouses should be like.

No possibility exists of collecting in one single preservation system all the vast range of variations that come together with respect to the films and which, in many cases, are totally uncontrollable from the archives.

On the other hand, availability of appropriate warehouses is not the only necessary condition to assure the preservation of the works; the films are preserved to be used and, consequently, the design of the systems of preservation will resemble the rest of the archive installations. The buildings in which the materials on which each work is preserved are studied, controlled and handled, as with all the equipment and systems used for handling, must be prepared and even conceived in order to help the preservation.

And, above all, in order to assure the preservation of the films, the archives must give the best and most extensive training for all the personnel who have to operate on its handling and on the tasks of preservation. The preservation of materials as complex as the ones received by cinematographic archives cannot be carried out with one single criterion. The archives must make many decisions (on each material or on the whole of the collections) which have to be adopted by personnel with a good scientific and technical training; and this training cannot be limited to the personnel in positions of responsibility in the organization ladder of the archives: the problems can be produced and/or detected in any situation, and to avoid or detect them is a task in which all the personnel of the archive have to participate.

The construction or conditioning of the buildings and equipment and the selection and training of the personnel are tasks which require serious economic resources, and they do not end with the final construction of the warehouses and the training and employment of the personnel.

The maintenance and renovation of the buildings, the energy consumption of the conditioning equipment and the continuous training of the personnel will still need very important economic investment for as long as the preservation lasts.

And it is necessary to bear in mind that not only people and materials get old: so do institutions.

- On designing the conditions in which to store the materials, the heads of archives cannot forget that these conditions shall be maintained over many years; even when they are not heads of archives anymore and even though the very archives themselves – as all such institutions –outlast a crisis which could threaten their continuity.

Experience has dramatically showed that the most destructive results have been obtained by archives which have stored their materials in conditions which they could not maintain through the years. The dilapidation of the warehouses led to the occurrence of massive damages in the films, damages which could possibly have been very much reduced if they had not stored the films in those conditions which are apparently more appropriate but harder to maintain.

There exists no single strategy for film preservation and each archive, on deciding upon its criteria of preservation, must weigh up the arguments that support different alternatives and they must do this heeding their own economic and technical possibilities.

The possibilities of conduct of the archives are related to traditions and the attitudes that are shown by society and the organizations (governments, cultural institutions, etc.) which support each archive, faced with conservation of cultural heritage and of the registers of the moving image.

The archives must clearly establish their technical and economic possibilities and – as far as it is possible to realize this forecast – evaluate the development of these technical and economic possibilities in the future of the archive. To make an error in these evaluations can be absolutely fatal for the preservation of the works we intend to preserve.

SECTION ONE
Classify to Preserve

The classification of the materials to be preserved is one of the basic activities of any type of archive and, moreover, is the activity on which preservation policies can be based.

In film archives, due to the fact that a large part of their materials are duplicates and that working on duplicates is synonymous with cinematographic activity, the development of classification systems should be based on a knowledge of the technical and functional characteristics of the materials and of the condition in which they have been kept, as well as on the determination of the relationship of each kind of material to the film to which it belongs and on the assessment of the importance it may have for the preservation of that film.

The classification of cinematographic materials is an extremely complex activity that is performed through inspection procedures, although the design of a unified inspection system encompassing each and every one of the archives would be impossible. Each archive, in line with its own policies and for the formation and use of its collections, must design its own *model for the systematic inspection of materials* and base the classification of its holdings on that model.

When focussed on the preservation of the films, the inspection of materials should provide the answers to two kinds of questions.

- The first refer to data that can be considered as permanent and that, once established in the initial inspection, should not be altered. Questions of this kind are, for example, those relating to the physical, chemical and functional characteristics of the material inspected, or with the relationship existing between each kind of material and the film to which it belongs.
- The questions of the second kind refer to data that could change or give different answers, depending on the condition of the material, when the inspection is performed and the needs of the archives. These are questions, for example, relating to the physical condition of the material and the state of preservation of the film to which the material belongs or to the possibilities and requirements of use of the material in accordance with the objectives of the archive concerned.

From among these questions, those relative to the characteristics of the material and its condition can be answered by means of a direct analysis of the material; however, in order to assess the importance each material may have with regard to the preservation of the film to which it pertains, it will be necessary to combine the analysis of the material with a study of the history of the film in question, and in order to evaluate the possibilities of use of the material, it will be necessary to combine all of the preceding information with the policies of preservation and access established by the archive.

Physical, Chemical and Functional Characteristics of the Materials

From their early days and up until after the 1950's, moving images could only be recorded and reproduced on transparent films made of plastic material, with one of the sides of the film (or sometimes both sides) coated with a solid layer comprised of organic gelatines and of the photosensitive crystals in which the images are formed.

With respect to cinematographic sound, up to the fifties, the only medium used were the same type of photographic films that were being used to record images. Starting in the 1950's, magnetic tapes would be introduced into cinematography up to the point of becoming the only support used throughout the entire of sound production stage, photographic supports being relegated to the reproduction and exhibition stages.

Also c. 1950, electronic technology and magnetic tapes began to be used as the medium for the recording of moving images. In the 1970's, the introduction of discs as combined image and sound supports would begin.[1]

Tapes, films or disks, photographic or magnetic recordings, photochemical or electronic technologies, the materials and systems used for the recording and the reproduction of images and sound always involve a common element: the criteria followed in their design and in the selection of their components have always been dominated by objectives of industrial functionality, and in order to become familiar with and to be able to preserve their materials, archives must give priority to a knowledge of that industrial functionality --technical and financial—which was a determining factor in their manufacture.

1 As the 1990's, for some image and sound production work, storage devices integrated into computers have been being used, as a result of which a new era is now possibly dawning in which the supports on which images and sounds are recorded are, at the same time, the reading equipment (or part of the reading equipment) necessary for accessing these recordings.

1 - Bases / Supports

The materials on which images and sound are recorded and reproduced are comprised by two basic elements: a sensitive layer and a base/support.[1]

The base/support must provide the mechanical characteristics necessary for the sensitive layer to be able to be used during recording and reproduction; as a result, the choice of materials for the supports has always been subordinated to the needs of the sensitive layer, and evidence exists of this subordination having contributed to many film conservation-related problems.

1.1 - Plastic Supports

All of the materials used for the manufacture of bases/supports for the recording and the reproduction of cinematographic images or sounds belong to the type of what we today know as plastic materials.

In cinematography, artificial plastic materials derived from cellulose (celluloid and acetates) and synthetic plastics such as polyester, PVC and polycarbonate have been used.

All of these materials are relatively economical, however, the manufacturing cost has not been the determining factor in their selection. The modern plastics have been developed parallel to the progress of cinematography and the latter has adopted (or at least tried out) all of those plastics that might possibly meet its needs.

The characteristics of the plastics used in cinematography valued most are their relatively high levels of dimensional stability and mechanical resistance as well as their characteristics of rigidity and flexibility.

Flexibility, when the materials are formed in thin sheets, is an indispensable quality for use in tapes that can be wound up, and transparency is also indispensable for photochemical film.

The stability of the plastic supports is considered in relation to the alterations, which the loss of that stability -- the chemical degradation of the plastic-- can introduce into the physico-functional characteristics of the film.

The chemical degradation is assessed, in the first place, by the dimensional changes brought about in the materials that may go so far as to prevent their normal use and damage the bond between the base and the emulsion; secondly, by the loss of the mechanical resistance of the support, and finally, by the action of the substances produced in the process of the degradation, which alter the transparency and decompose and destroy the film.

The loss of the plasticiser is evidenced through dimensional changes and by the loss of flexibility, involving the possibility of the film becoming completely rigid and deformed.

The absorption or the loss of moisture also has direct effects (independently of those brought about by the chemical degradation) on the dimensions of the support and on its transparency and binding with the emulsion.

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1 Solely in some systems in which the reproduction was done by embossing (such as some types of discs) the materials did not adhere to the basic scheme.

The causes and the effects of all of these processes are closely related and can mutually enhance their impact.

1.2 - Reels / Films

Until relatively recent times, the only supports used in cinematography were thin plastic films in the form of reels.

A reel makes it possible to record large amounts of information and, despite the fact that a reel can be hundreds of meters long; it can be wound up and handled with relative ease.

For it to be possible for a material to be used as a base/support in reel form, it must be of certain characteristics entailing dimensional stability, rigidity and flexibility and, transparency for photographic supports.

The width and the thickness of the supports and their strength and flexibilty-related characteristics are determined by the combination of the qualities of the recordings aimed at being achieved and the resolution and feeding-related possibilities and needs of the emulsions and of the recording and reproduction systems on which they are going to be used.

1.21 - Dimensional Stability

Changes in the dimensions (width, length, thickness) of the support can be detrimental, to the extent of making it impossible for them to pass through the equipment, and can weaken or break their bond with the sensitive layer.

In reels, the effects of the reduction (contraction/shrinkage) or the increase in any of these dimensions progress differently depending on whether the longitudinal or the transversal direction of the film is involved and this fact has a multitude of effects with regard to preservation. [2]

On contracting or stretching unequally lengthwise and crosswise, the films bend and undulate (winding), losing their flat surface, thus weakening the splicing points and increasing the risk of tearing when handled.

The effects of contraction are particularly serious in the sprocket-hole films characteristic of photochemical technology, and although the longitudinal contractions are less than those produced in a transverse direction in percentage terms, relatively minute lengthwise contractions can even prevent the normal use of the films in projections or in duplicating.

The transversal contractions or expansions are resolved in the width of the film and, to a certain extent, are absorbed by the allowances of the rollers and guides through which the film passes; in contrast, the longitudinal contractions accumulate, and a relatively small contraction will mean that, after a few frames, the sprocket holes are closer together than the teeth of the rollers, causing sliding or even tearing, thus preventing the normal use of the materials.

The changes in thickness and their most significant consequences arise from the relationship between emulsion and support, these will be discussed in a later point devoted to films on reels will be discussed in Section 6 devoted to roll film preservation.

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2 In principle, following the manufacture of the plastic material, the linear macromolecules of the polymer are oriented in all directions forming balls, however, on spreading the mass in order to form thin films, the molecules oriented lengthwise are stretched more than those oriented transversely and, as a result, the changes in length the molecules may undergo will be different depending on their orientation. In most of the processes, the macromolecules that are oriented in a longitudinal direction (stretched to a greater degree) will contract less than those oriented transversally.

1.22 – Tensile Strength, Flexibility and Rigidity

These three mechanical characteristics should be considered jointly and depending on the needs of the transport and reading equipment used in each reproduction system.

1.221 - Tensile Strength[3]

In all of the plastics used in the manufacture of motion picture film, the tensile strength is relatively very high (over 600 kg per cm^2 section in the weakest[4]) and more than sufficient for normal operating requirements, however, the operating requirements are not always normal.

When the reels do not operate as smoothly as they should or jams arise in the pulling motion or when hasty or incorrect manipulations occur, the tautness that the film must overcome could increase to the point of exceeding the elastic limit and cause deformation or even breaks. In this sense (and in others) the introduction of cassettes as storage and handling devices has considerably improved the preservation of the supports.

The chemical degradation of film leads to the breakup of the molecular chains formed by the polymer, reducing the mechanical resistance of the supports; however, this process is extremely slow and, by the time the loss of strength produced by the structural degradation of the support can directly endanger or prevent the use of the material, the latter will have already been damaged by the effects that the chemical degradation proper and the de-plastification will have caused on its dimensions, flexibility and rigidity.

1.222 - Rigidity and Flexibility

Despite being apparently contradictory, the plastics that can be used as a support in cinematographic films must combine a certain degree of rigidity and a certain degree of flexibility.

The requirements of rigidity for photochemical films are greater than those for the tapes used in the magnetic systems, and much greater than those of the tapes when they are encased in cassettes.

In the electromagnetic systems, the tapes travel at a constant speed, and the tape is positioned on the play-back heads subjected to an even and continuous tension. Under these operating conditions, the rigidity necessary for their operation can even be relatively small, only just enough to keep the tape flat when it is not subjected to tension. Apart from this, the tape must be sufficiently flexible (not elastic) so as to be able to adapt itself, in direct contact without sustaining any damage, to the surfaces of the tape head.

In the photochemical systems, the rigidity of the films must allow them to pass -- completely flat and with lateral support only – in front of the gate, while they slide by in a succession of pulls and stops and, moreover, in the case of projection prints, while they must withstand the force of the heat from the light of the projector lamp without bending. The rigidity of the support must also be

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3 The tensile strength should be considered jointly with another parameter of mechanical strength: *elongation to the breaking point*. Any material subjected to tension undergoes an elongation that develops in three phases: elastic elongation (which disappears when the tension ceases), major elongation (which involves irrecoverable deformations) and breakage.

4 Which, for a 35mm film means a tensile strength of more than 20 Kg.

sufficient in order to distribute throughout the film the thrust that the claws or sprockets exercise on the extremely delicate edge of the sprocket holes.[5]

In the photochemical supports, the flexibility will only be necessary in order to achieve the winding-up of the reel and its transit through the sinuosity of the winding systems. The combination of rigidity and flexibility must provide a certain degree of elasticity capable, for example, of allowing the operation of the loops formed by the change from continuous to intermittant movement.

In the operating conditions of these films, any loss, including a relatively minimal loss of tensile strength, of rigidity or flexibility will inevitably lead to the deterioration of the film.

With respect to the plastics derived from cellulose, the rigidity is provided by the structure of the polymer itself and the elasticity stems from the plasticiser. The loss of the plasticiser detracts from the conditions of elasticity and increases the rigidity.

The proportion of the plasticiser in the mass of the supports is a negative determining factor of its chemical stability, and plastics such as polyethylene terephthalate (PET) in which the proportion of plasticiser is much lower, tend to retain their functional qualities better.

1.223 - Transparency

In photochemical films the transparency and the absence of pigmentation are essential qualities for the bases/support.

All transparent materials absorb and disperse a certain amount of light, however, considering the thickness of the materials used in these films (around 125 micra), these quantities are minimal: approximately 5% of the light they receive.

Almost all of the transparent plastics present a certain degree of pigmentation (generally yellowish), which may increase as a result of the effects of light; however, in normal conditions of use and maintenance and with the thicknesses used in motion pictures, this pigmentation is not appreciable.

The refraction index is another important aspect in the photographic plastics. In those used in the film industry, this index is around 1.5%, higher than that of water and practically the same as that of the lightest grades of optical glass.

The structural degradation severely alters all of these parameters, and could even turn the support into an opaque strip. Also, but to a much lesser extent, the absorption of moisture can alter the transparency of the support. The loss of the plasticiser introduces very few changes in this regard.

1.3 - Discs

The phonographic discs used in the first attempts at introducing sound operated on the basis of mechanical or electromechanical systems that required extremely rigid supports. In these, artificial plastics were used, (which were) obtained from products such as rubber-lacquer and soot and were hardened by the addition of limestone or other minerals.

The rigidity of those discs made them extremely fragile and easy to break. Moreover, the industrial requirements for their manufacture and embossing

5 In order to achieve the rigidity and the elasticity necessary, photochemical films must have a relatively high thickness (above 0.110mm); with respect to the cellulose supports, this thickness provides the necessary tensile strength, however, when polyesters are involved, the tensile strength may be excessive and, if jamming occurs in the movement of the film, it could damage some of the components of the machinery.

made it impossible to provide them with the hardness necessary in order to withstand the aggression of the needles reading them, which led to the inevitable production of scratches and other mechanical damage after very little use.

The motion picture sound systems based on discs were soon abandoned, not because of the fragility of these elements; in these systems, the synchronisation between images and sounds was brought about by means of mechanical devices that regulated the speed of the gramophone in line with that of the projector, but were incapable of providing a solution to the loss of synchronisation produced by film breakage.

In the early seventies, a whole range of videodisc systems emerged, designed for recording and reproduction in the professional environment of television or for reproduction in household equipment; these systems used discs of between 16 and 12 inches (40.5 and 30.5mm) in diameter and different types of support and were accepted to different degrees.

The first of these systems[6] used 16-inch aluminium discs, coated with a magnetic layer of nickel-cobalt, obtaining recordings with duration of 30 seconds.

In most of these systems, plastic materials were used in the manufacture of the discs and, the same as with the phonograph discs, the recordings were made by embossing. [7]

In several of these systems the surfaces (and the discs themselves) were very fragile, principally those that allowed direct recording, where the discs had to be kept permanently protected in cases.[8]

The structural model on which the videodisc systems became consolidated started with the LaserVision by Philips, a system in which the information is recorded by means of a number of depressions –in a spiral arrangement, like the phonographic discs—made by embossing a polycarbonate disc, later coated with an extremely thin reflecting layer and protected with a further layer of a transparent acrylic plastic.

In this system, a monochrome, coherent beam of light (laser) is focussed on the bottom of the depressions and the variations in the light reflected, from the focal point or from the surface of the disc/support, carry the information to the read head and allow the reader to "advance" along the track of recordings. In all else, the LaserVision system functions like a videotape recorder.

The "laser-read" discs, with their recording surfaces protected by a transparent plastic layer, are practically immune to mechanical damage and to dirt. Also, as the laser is focussed on the bottom of the recording groove, the scratches and stains on the surface have very little effect on the reproduction.

In these operating conditions, the plastics selected for the base/support can be much less rigid and fragile and have considerable elasticity, which converts the discs into highly resistant elements.

The large-diameter embossed videodiscs never were a great success and, in the course of the nineties, they eventually disappeared from the market.

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6 The AMPEX HS 100

7 In the TELDEC and the RCA systems, which used 12-inch metal and PVC discs, the similarity with the phonographic discs went as far as the use of groves for guiding a reading “needle” that picked up the information recorded.

8 As in the direct-recording SONY videodisc.

The laser-read discs for audio were developed in parallel to the videodiscs and, in 1980, a basic industrial standard was developed for the manufacture of these discs. The development of these discs, in which the information is encoded digitally, has almost pushed the electromechanically-read phonographic discs out of the market and has led to the advent of new generations of videodisc systems that use the same support as the audio discs, with which they even can share some reproduction equipment.

The basic standardisation covers the diameters of the disc (120mm), of the central adjustment hole and of the recording and reading areas, as well as the thickness (1.2mm) and the layer structure.

These discs, extremely light in weight and very elastic, are highly resistant to the mechanical damage that can arise from normal wear and tear, however, given the density (amount) of information recorded on each square millimetre of the useful surface of the disc, the dimensional stability of the support is a much more critical factor than in either of the other types of audiovisual supports.

The discs have appeared on the scene once again in the middle of the nineties, as supports for motion picture sound.

The sound track is recorded on a CD and the synchronisation is controlled by means of a code photographically reproduced on the prints, which, in the event of breaks occurring in the films (with the resultant splicing) makes the sound reading on the disc advance automatically, simulating the missing frames brought about in the film and maintaining the synchronisation.

1.4 - The Cinematography Plastics [9]

The plastic materials used for motion pictures can be divided into two types: artificial plastics derived from cellulose and synthetic plastics.

1.41 - Artificial Plastics Derived from Cellulose

These plastics are obtained by altering the structure of the original cellulose, replacing the hydroxyl groups (OH) in its molecular rings with nitro or acetate groups. The nitrates or acetates so obtained have, by means of the addition of a plasticizer, plastic characteristics and a certain degree of flexibility.

Despite their similar origin and characteristics, nitrates and acetates are materials with very different problems and manufacturing processes; differences that have multiple consequences in their maintenance and that can be easily understood through the difficulty achieving the degree of substitution (nitration or acetylation) desirable for each material.[10]

In the cellulose trinitrate originally obtained by Schömbein, the degree of substitution was between 2.7 and 3. That material was explosive and the difficulty (of obtaining products that were only inflammable) was in lowering the degree of substitution to a point included between 1.9 and 2.7. The nitrocelluloses having the lowest degree of substitution were used for the manufacture of motion picture films.

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9 In the drafting of this entire chapter, the information was drawn basically from data and texts of:
Catalina, F. et al.: "Los materiales plásticos celulósicos en los soportes cinematográficos". *In: Revista de plásticos modernos, no. 457 and 458, FOCITEC, Madrid, July and August 1994.*
Catalina, F.: "Soportes cinematográficos basados en triacetate de celulosa". *In: Los soportes de la cinematografía, Filmoteca Española, Madrid, 1999.*

10 The degree of substitution represents the quantity of OH groups that is nitrated or acetylated in the rings of the molecular chain of cellulose. As each ring contains three OH groups, 3 is the maximum degree of substitution possible.

With respect to the acetates, the story is completely the reverse. The most stable acetates and with less permeability than water are those with the highest degree of substitution, however, achieving the acetylation of the hydroxyl groups of the cellulose was not easy, in order to progress from the initial diacetates, obtained in a laboratory in 1895, up to the triacetates with a degree of substitution of approximately 2.7, it was necessary to undertake a long journey that would last up to the forties in the 20th century.

In the cellulose derivatives, the plasticiser constitutes a significant percentage of the mass of the material and, to a large extent, the physical properties of the plastics and their characteristics of stability depend on their plasticiser content.

The plasticisers perform a dual function: first, they lower the pour point temperature of the cellulose derivative, separating it from the decomposition temperature, and enabling it to be moulded or hot-rolled; second, when cold, they reduce the rigidity of the cellulose providing the plastic with flexibility.

The loss of the plasticizer, which can proceed from the chemical instability of the product used as a plasticizer or which can be the consequence of the structural degradation of the material, leads to changes in dimension and increases the rigidity of the supports.

1.411 - Celluloid or Plasticised Cellulose Nitrate

Celluloid was the first material that offered the appropriate characteristics for use as a motion picture support.

Cellulose nitrate was obtained for the first time[11] in 1846 as a material so chemically unstable that it would explode spontaneously. Over the following years, by controlling the reaction speed and eliminating impurities from the components, a type of solely flammable nitrates were obtained, that is, the pyroxilins, which, when dissolved in alcohol and ether would be used in photography as an agglomerate for the silver on the plates sensitive to the moist and dry collodion. In 1854[12], by means of the addition of camphor to the mixture made with alcohol and ether, a transparent, stable and resistant material was obtained, with a very low tendency to absorb moisture, that could be hot-moulded and hot-rolled and cold-mechanised. The industrial manufacture of this product was initiated[13], under the commercial name of Celluloid, in 1872. In 1889, George Eastman used it in reel form as a support for his photographic films, and later, with the collaboration of K.L. Dickson, as a support for the films of Edison’s Kinetoscope.

Eastman Kodak suspended the manufacture of celluloid in 1951, and celluloid was very gradually abandoned during the 1950's as the support for motion pictures throughout the world[14].

Cellulose nitrate is a cellulose derivative, obtained by the nitration of the original cellulose in the presence of sulphuric acid, which acts as a drying agent by

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11 By the German chemist, *Christian Friedrich Schömbein*

12 By the English chemist, *Alexander Parkes*, who called it *Parkesine*.

13 By the American inventor, *John Wesley Hyatt*, who in 1869 heard of the plasticising procedure of nitrocellulose created by Parkes.

14 Kodak closed its production lines for this plastic in 1951; Agfa offered its products in triacetate in 1952; around 1954 Gevaert stopped manufacturing nitrate supports and Fuji changed all of its supports in 1958.
In each country, a distinction should be made between the date of the end of manufacture and the date of the end of use. In Spain, the manufacture of film in celluloid stopped in 1952, but it was still used in filming and reproductions up to 1954, and in projection until many years later.

eliminating the water produced during the transformation. The nitrogen content of the commercial nitrates varies between 10.7 and 11.2%, instead of the 14.2% of the original trinitrate.

The camphor, which was the first and almost the only product used as a plasticiser for the nitrates, is a crystalline, translucent and highly volatile substance, and this volatility became an ongoing problem for the preservation of the celluloid.

Celluloid is a highly resistant material[15] and very transparent. It has a slightly yellow colouring that does not interfere with its use in cinematography. Its tendency towards the absorption of water is very low[16] which contributes to its dimensional stability. Its mechanical qualities are altered at temperatures above 80ºC. It dissolves easily in a number of products, such as acetone, carbon tetrachloride, methyl acetate, etc.

The most evident effects of the chemical instability of celluloid are its flammability and structural degradation (decomposition). Both manifestations are strictly related.

The chemical decomposition of the celluloid produces heat, for which reason the flameless combustion of the celluloid begins at temperatures below the ignition point. If the heat produced builds up without dissipating, the temperature of the material will progressively increase until it reaches 160ºC, at which point the celluloid will ignite[17].

The nitrocellulose contains large amounts of oxygen in its structure and does not need outside oxygen either for feeding its flameless combustion or for its ignition.

When it burns, an isolated strip of celluloid can be extinguished by cooling it violently with gas, water or foam, however, there are no systems capable of extinguishing a roll of burning film; the coolants cannot penetrate to the inside of the convolutions and since, to burn, the celluloid uses the abundant oxygen contained in its structure, preventing the supply of air to the film is useless.

All of the gases released by the decomposition and combustion of celluloid are toxic and some are very dangerous (particularly when combining in environments without ventilation - a condition in which they can even become explosive), thus, the storage areas for celluloid should be appropriately insulated and ventilated.

Celluloid decomposition begins as soon as it is manufactured. The fragmentation of some N-O bonds in the nitro groups, gives rise to breakage in the molecular chains producing nitrous oxides which, on combining with the moisture, go on to produce nitric acid, which acts a catalyst precipitating and accelerating the decomposition process.

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15 See: Textual Note I

16 A sample of celluloid, maintained for 24 hours at 100% humidity and at a temperature of 20 degrees, will absorb between 1.5 and 2% of water.

17 Apparently, 160ºC is a sufficiently high temperature in order for it to be considered as unlikely to be attained without the contribution of heat from an external source, however, in a roll of film stored at 40º the production of gases by the structural decomposition increases very quickly and if (on account of the pressure existing between the successive convolutions of the film) the gases cannot escape to the outside, the pressure exerted by the gases between convolutions in the interior part of the roll will make the temperature rise rapidly and 160ºC could be reached within relatively a few hours' time.

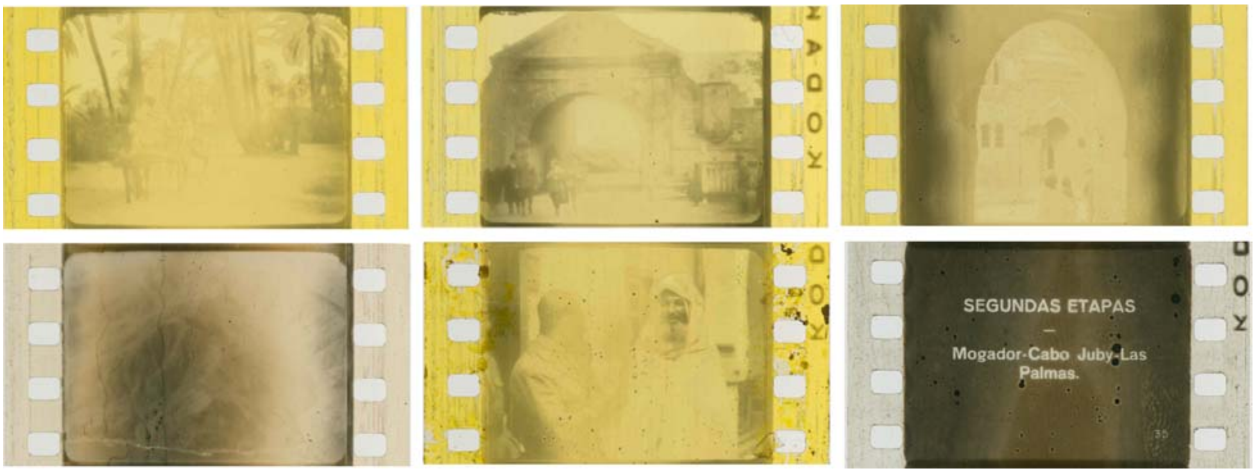
In principle, the chemical decomposition develops very slowly and its external signs (odour, contraction) are confused with those derived from other processes such as the loss of the plasticiser. When the decomposition reaches the "active" phase, where its effects are clearly visible, it can continue to advance slowly over a long period of time or it can quickly precipitate its progression to the total destruction of the material.

Although experience shows that there are enormous differences in preservation between different rolls of this material, it is possible to predict that – regardless of how the films are stored – in the long term all of the celluloid film prints will become victims of decomposition.

Although these terms may not be entirely correct, the initial phase of decomposition, in which the external signs are not clearly perceptible, tends to be described as "inactive or latent decomposition". A number of laboratory tests have been standardised in order to determine the chemical stability of the material throughout this period.[18] These tests are not absolutely exact, however (within certain time limits) they can provide reliable orientations as to the expectations regarding the useful life of each material and afford the possibility of scheduling preservation duplication.

The second phase of decomposition – active decomposition – can begin as a result of the development of the internal processes of decomposition of the material itself or on account of a direct external aggression against the film. Although the effects of the decomposition are basically identical in both cases, being able to distinguish between the endogenous and the exogenous processes can be very important from the viewpoint of the control of the maintenance conditions in storage areas.

A careful observation of the initial characteristics of the active decomposition in each film can enable us (with reasonable accuracy) to establish how and why the active phase began and perhaps, the remedying of its causes.



F.1: Endogenous decomposition

In the endogenous processes, the decomposition generally begins in the centre of the frame, in an area where, for example, due to an increase in the pressure between convolutions, the gases arising from the degradation are unable to escape to the outside and unleash an increase in the temperature and, consequently, in the

18 The procedures for conducting these tests are discussed in the paragraph 8.13 of this document.

degradation speed. This type of process does not tend to begin in the exterior convolutions of the rolls, in which the pressure is not sufficient in order to encapsulate the gases produced by the “latent” degradation.

For the exogenous processes, two typical origins can be described: in the first case, the process tends to begin on the side of the roll placed on the bottom of the container, when the water manages to penetrate into the container or to condense (due to changes in the humidity and temperature) inside; in the second case, always associated with a splice, a fold or some other interruption in the continuity of the roll, the process originates with the condensation of the moisture which (by capillary action) manages to penetrate into the interior of the convolutions. These types of degradation, including when they have scarcely begun, tend to be accompanied by serious damage directly caused by moisture in the photographic gelatines.

F. 2: Exogenous decomposition

The active decomposition of the celluloid has been extensively described and classified into five different phases.

- Phase 1 - Decomposition initiated

The material can still appear to be in perfect condition to the naked eye, however, it seems moist to the touch. The photography can be in perfect condition or show slightly coloured or faded areas running lengthwise along the centre of the frame.

In the endogenous processes, the decomposition may have begun next to the central core, in the convolutions more to the inside of the roll, or (in negatives, prints with editing or reconstructed prints) may affect only one of the types of the material comprising the roll.

In the exogenous processes, it may be located around a spliced area or fold or at some point of the edge that may have been affected by moisture or the rusting of the container.

- Phase 2 – Serious decomposition

The support or the emulsion are slightly sticky to the touch and, on rewinding, the roll makes a slight noise (like something that is coming unstuck).

The discolouring or fading of the image is clearly perceived as unequal density stains.

In some irregularities of the roll, stains may have appeared (including with the total destruction of images) which become decomposition-generating nuclei, spreading the decomposition to the frames in contact with the adjacent convolutions.

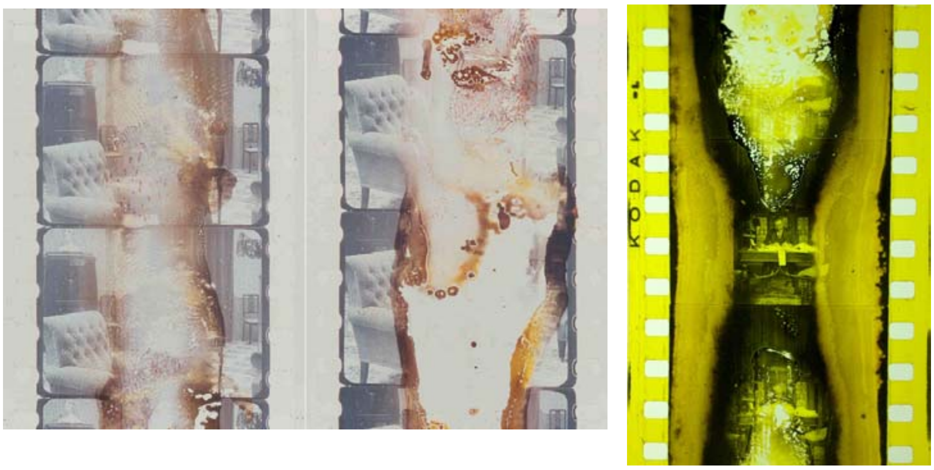
The damage to the edge goes beyond the perforations and affect the areas of image or sound.

In the two preceding phases, it is still possible, if quick action is taken, to reproduce the material, however, it must be handled with extreme care, as the material will probably have lost many of its mechanical characteristics, becoming weaker and less flexible, and could break under any kind of increase in tension.

- Phase 3 – Very serious decomposition

The material is clearly sticky. The stains, in which the support has lost transparency and the image may have "moved" and become deformed or even may have disappeared into a blurred "smudge", can extend over a number of meters of film or affect one or more frames through many successive convolutions.

The images destroyed cannot be recovered , only an occasional isolated photograph can be obtained.



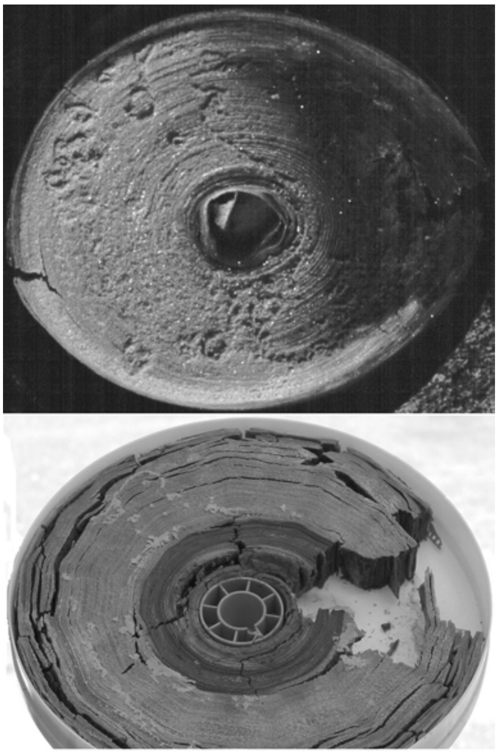
F. 4 - 5: Endogenous decomposition

F. 3: Exogenous decomposition

- Phase 4 – Total loss

F. 6: Progression of the decomposition in the last three shots of a reel

The entire roll or large parts of it have become a solid, sticky mass with exudations of a viscous and bubbling nature (nitric honey). The film has taken on a brownish shade and translucent appearance and there are no vestiges of photography. The rewinding is difficult or impossible and material that can be separated from the roll splinters with the fragility of a crystal of gypsum.



- Phase 5 - Final

The material forms a solid, crystallised block that tears and cracks (by the effect of extreme contractions) like clay earth following a flood. The decomposition process is still active and the entire roll will end up as dust.

F. 7: Reels in the last stage of decomposition

Despite the fact that this kind of description in phases can give the impression that the decomposition process advances step by step, this is not the case. Often, in the same roll, areas will be found that are completely destroyed while others are apparently stable. Solely in the final phases will the violence of the process affect the entire roll.

Although the irregularities in the progress of decomposition have not been studied, empirically it can be stated that the decomposition affects films of different types or manufacturing lots in an unequal manner, including films produced by the same manufacturer and belonging to the same lot but dyed in different colours.

Even more inexplicable is the continuous detection of materials in which deterioration has stopped progressing; materials that, despite having shown evident signs of having initiated the decomposition process years ago, appear completely dry and even rewindable, including in the areas affected.

The storage conditions – temperature, humidity and ventilation – are determining factors for the development of decomposition.

In the studies consulted, the relationship between the temperature and the structural degradation of the nitrocellulose is quantified with respect to the relationship existing between the temperature and the production of nitrogen dioxide and nitric acid, which are the agents which will catalyse and precipitate the decomposition reaction. Herbert Volkmann stated: "*The amount of gases released depends on the storage temperature. Reducing this temperature by 5ºC represents a 50% reduction in the production of nitrogen dioxide: that is, by* *reducing the temperature from 20ºC to 3ºC the amount of gases released is reduced to less than one-tenth of the original amount* ".[19]

The relationship between moisture and degradation, although empirically it can be said that it is indisputable, it is in fact not as evident as that existing between temperature and degradation. Films have occasionally been located which are so seriously affected by moisture that it had gone as far as to dissolve areas of the emulsion, while the support remained (and remains) intact and transparent.

The combination of high temperatures and humidity levels is very destructive for the nitrate supports, however, the lack of ventilation is the factor that can lead to each one of these parameters - and even more so, the combination of the two - accelerating the degradation of the celluloid to the point of advancing the decomposition to its active phase and even to the destruction of the films.

In the course of the preparation of this text, no studies quantifying the relationships between decomposition and the condition of humidity and ventilation during storage were found.

Neither were studies found on the degradation caused by the loss of the plasticiser in the celluloid films.

1.412 - Acetates

The cellulose acetates, under the generic name of "safety films", were the materials that replaced celluloid in the making of motion pictures.

Unfortunately, the terms “safety film” are only justified by the fact that these plastics are more difficult to burn and are absolutely not self-inflammable, but from the standpoint of the conditions necessary for their preservation, acetates have turned out to be just as demanding as the celluloid.

Cellulose acetate was prepared for the first time in 1865. In 1909 the first non-inflammable cellulose materials were produced that were suitable for making flexible, transparent films, based on cellulose acetates.

In 1910, Kodak placed on the market 35mm films with cellulose diacetate supports[20], which were not very successful. In 1912, Pathé used the diacetate for his Pathé Kok films, aimed at the non-professional market[21]. In 1922 and 1923, once again Pathé and Kodak presented their 9.5mm and 16mm systems, in which they used new, more stable types of diacetates.

Throughout the thirties and forties, a succession of triacetate supports were introduced on the market, but without succeeding in being widely used in the motion picture industry, although they were applied to other uses such as, for example, radiographic plates. In 1948 Gevaert introduced a new plastic, cellulose acetate-butyrate and, that same year, Kodak commenced the

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19 Volkmann, Herbert: “The structure of cinema films”. In *Preservation and restoration of moving images and sound. Chapter 1.* FIAF, Brussels, 1986
Volkmann, Herbert: "Aspectos técnicos de la conservación de images en movimiento". *In: Boletín CIDUCAL, no. 1, CIDUCAL-UNAM, Mexico, 1980.*
Volkmann, Herbert: "Preservación". *In: Bowser, Eileen and Kuiper, Jonh (edit.): "Manual para archivos filmicos". Boletín CIDUCAL, no. 3, FIAF-CIDUCAL-UNAM, Mexico, 1981.*

20 See: List of Kodak film products, *in Kodak Web-site.*

21 Lone, Eric "La manufacture de película en Francia antes de 1929". Paper given at the FIAF Congress in Madrid, in 1999. Published in*: "Archivos" no. 32 - Filmoteca de la Generalitat Valenciana, Valencia, June 1999 - pp 84 to 93.*

manufacture of the type of triacetate that would eventually replace celluloid completely.

As pointed out in the introduction to the cellulose derivatives, the manufacturing process of acetates presents, in many aspects, the opposite difficulties to those involved in the nitrates.

The most stable acetates are those with a greater degree of substitution (acetylation) however, achieving this acetylation renders the manufacturing process extremely complex, making it necessary to introduce processes for the pre-conditioning of the cellulose and rendering it difficult to obtain homogeneous products, to the point of necessitating the mixture of acetates in order to achieve the desired quality. These difficulties explain the lengthy history of the successive appearances and disappearances of diacetates and triacetates and of the attempts to incorporate the use of combined esters, such as the acetates, butyrate and propionate.

In contrast to celluloid, acetates can serve as preservation materials.

Cellulose nitrate initiates its structural degradation due to its own chemical instability and at the very moment of its manufacture. Controlling the storage temperature and humidity will allow celluloids to degrade very slowly, but will never halt this process completely.

On the contrary, inappropriate temperatures, humidity levels and ventilation are the factors that will give rise to acetate degradation and that can convert this degradation into an extremely rapid process, capable of destroying entire collections in a short amount of time. However, if the films are kept at the proper temperature and humidity, the acetates (or at least their more stable varieties) will not start the degradation process.

1.412.1 – Cellulose Diacetates

Cellulose diacetate has been described as "a partially hydrolysed ester"[22] and, in fact, in each of the rings of the molecular chain of the modified cellulose, remains at least one OH group not substituted, and these groups convert the diacetate into a material that is very permeable to moisture.

We cannot refer to diacetate as if it were a single plastic. Even though the information available for drafting this text is manifestly scant, it is evident that substantial differences must have existed between the first materials used by Kodak and Pathé and those used by these same manufacturers as from 1922-23.

In the text published in 1990 by the Preservation Commission of the FIAF[23], Henning Schou pointed out that in some diacetates, remains of sulphates have been detected (which noticeably increase their susceptibility to moisture) as well as the use of plasticisers, such as monochloronaphthalene, which are extremely volatile and contribute to an early loss of the mechanical and dimensional characteristics.

The levels of the mechanical characteristics of diacetates are far from those of celluloid.

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22 Tristsmans, R.G. "Le nouveau support des films cinématographiques Gevaert". *Dans: Le Cinéservice Gevaert, feuille Q/110, Mortsel, May 1949.*

23 Schou, Henning et al.: "Préservation des Films et du Son". *FIAF Preservation Commission, Brussels, 1990.*

An interesting study, published by Gevaert in connection with the launching campaign of the aceto-butyrate[24], presents comparative tables of the characteristics of nitrates, diacetates, A-butyrates and triacetates. On these tables and with respect to the nitrate, the diacetate is shown with between 1/4 and 1/5 less tensile strength and elongation to the breaking point, and with between three and four times the susceptibility to water absorbtion and to elongation in damp conditions. (see: Textual Note II)

Naturally, at the time, Gevaert had no interest whatsoever in revealing good qualities of the diacetates, however, the magnitude of the data is significant.

As could be expected of a plastic that has undergone many variations and modifications, in the eighty years have already passed since the large-scale launching of the diacetates, it can be said that their behaviour with respect to preservation is extremely irregular.

In general, those used by Pathé have performed better than those of other manufacturers. With many exceptions, Pathé's 28mm materials, including very old ones, may reveal slight contractions and few deformations; on the contrary, 9.5mm materials can present strong deformations and a degree of rigidity preventing their use in any way whatsoever [25]. Very often, on recovering Kodak materials from the 20's and the 30's, the rigidity and the degree of undulation presented by the roll preclude the use of the film.

1.412.2 – Combined Esters: Acetate-Propionate and Acetate-Butyrate

Prior to the development of cellulose triacetate plasticised with triphenylphosphate, due to the defects in the mechanical behaviour and, above all, due to the major moisture-absorbing tendency of cellulose diacetates, two combined plasticised esters would be introduced into film manufacture, acetate-propionate and acetate-butyrate, which were manufactured by several chemical product manufacturers (such as Kodak and Bayer) and used by Kodak and by Gevaert in the manufacture of cinematography supports.

For these plastics, the cellulose is sterified by way of a mixture of two acids, that is, acetic acid and propionic or butyric acid.

The qualities of these two plastics are quite similar. Both are slightly lighter in weight than nitrate or acetate, have a slightly lower refractive index, and their mechanical qualities are inferior to nitrate but superior to those of the existing diacetates at that time. Acetate-butyrate has proven itself to be highly resistent to moisture absorption (although inferior to that of nitrate).[26]

The qualities of these materials were certainly superior to those of the diacetates, however Kodak and Gevaert practically did not manufacture 35mm material on this support. (see: Textual Note II)

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24 Tristsmans, R.G.: Op. cit..

25 On observing these deteriorated 9.5mm materials, it becomes evident that the shape and position of the sprocket hole strip has facilitated the decay in question.

26

Cellulose plastics. Indicative values compared for combined esters, nitrate and acetate				
	A-Propianate	A-Butyrate	Nitrate	Acetate
Specific weight	1.19 - 1.23	1.15 - 1.22	1.27 - 1.32	1.35 - 1.40
Refractive index	1.46 - 1.49	1.47 - 1.48	1.47 - 1.5	1.5
Tractile strength	24-50	17-52	24-76	35-70
Ultimate elongation	30-100	8-80	5-55	10-40
Moisture absorption	1.5 - 2.8	0.9 - 2.4	0.6 - 2.0	1.0 - 3.0

Extracted by: *J.A. Buydson " Plastics Materials " 3rd revised edition.* Butterwooth Scientific - Instituto de Polímeros y Cauchos, London - Madrid, 1975.

1.412.3 – Plasticised Cellulose Triacetate

Starting in the fifties, triacetate became the fundamental plastic for the manufacture of bases/supports for motion picture films.

From the beginning, the archives were delighted with the new plastic, which, at the present time, constitutes the basic support for the great majority of collections. However, in 1957, scarcely 10 years after the commencement of the industrial manufacture of the product, archives located in hot and humid climates began to report processes of chemical degradation.

The manufacturers replied by indicating that the film with plasticised cellulose triacetate supports needed to be stored at a temperature of between 17 and 27°C (60 - 80°F) and a relative humidity of between 40 and 50% HR[27], conditions comparable to those recommended for any other type of archive as well, but which very soon proved to be insufficient for film archives.

The chemical degradation of the triacetates –which is very appropriately known as the "vinegar syndrome "—represents a most serious problem: the archives hold thousands of millions of metres of film with a triacetate support.

The strategy adopted for the celluloid films --reproduce the materials to preserve the films—is a strategy which has still not been concluded for that type of support and would be completely impossible to propose for the enormous volumes of the collections on triacetate; moreover, this strategy is not the only possible solution for the triacetate: if kept in adequate conditions, the triacetate supports can serve as genuine preservation supports.

The manufacture of triacetate is a very complex industrial process, subject to multiple variables that are not completely controllable.

The manufacture of motion picture film takes place in two stages.

- In the first stage, manufacture of the triacetate[28], the process is initiated by preheating the cotton for 1-2 hours, impregnated with 30-40% of its weight in glacial acetic acid. The acetylation reaction takes place in a mixture in which, for every 100 parts of pre-treated cellulose cooled at l5-20°C, 300 parts of acetic anhydride, 400 parts of methylene chloride and 1 part of sulphuric acid are introduced.
- In the second stage of the process, the triacetate (which arrives in the form of flakes) is dissolved, and a very viscous mixture is obtained, to which plasticizer, together with any other additives considered necessary, are added. The mixture is spread on an endless conveyer belt and passes through a drying section in order to remove the solvent.

The properties of the plastic thus obtained will depend on the length of the chain of the cellulose molecules (the degree of polymerisation, represented by the number of monomers forming the polymeric chain), on the degree of acetylation (substitution) and on the type and amount of the plasticiser.

The degree of polymerisation of the compounds obtained in the manufacturing process is within the interval of 175-360. A degree of substitution of 2.7 indicates that the majority of the rings of the polymer (90%) have their three OH's substituted, however, it also indicates that there are hydroxyl groups free and ready to associate themselves with the moisture.

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27 Eastman Kodak Co.: "Storage and Preservation of Motion Picture Film". *Motion Picture Film Department, Rochester, 1957.* (see: Textual Note III)

28 There are several systems. The procedure indicated is the so-called Dormagen process, developed by I.G. Farben. (see works quoted in note 11)

The difficulties of obtaining a specific degree of polymerisation, together with the difficulties in order to obtain a homogeneous substitution, and to the highest possible degree, forced manufacturers to make mixtures using different lots of triacetates until a material of the desired characteristics was obtained.

The fact that the obtaining of the triacetate sought, with absolute precision, involves so many difficulties and that it must be achieved by means of a mixture, inevitably leads to having to admit that (as was already the case with the diacetates) when dealing with a triacetate, we are referring to a material that can be found to have significant differences with respect to its properties -- and for its preservation—depending on where (what factory) and when it was produced.

Without a doubt, were their detection to be possible, these differences would explain the ageing-related differences that are constantly detected among apparently like films, which have been stored under exactly the same conditions.[29]

In the manufacture of motion picture films, triphenylphosphate is used as a plasticiser and also acts as a stabiliser and flame-retardant agent as well. In the triacetates, the plasticizer can account for 11% of the total mass[30]. The flexibility of a motion picture film depends on the plasticizer. The loss of the plasticizer will determine the loss of the flexibility of the film, but also a significant dimensional loss (contraction).

The triacetate is not self-inflammable and its flash point is around 430 degrees. The combustion of the triacetate, both at temperatures below the flash point as well as those above it, is much slower than in the case of the nitrate, and in addition it has the advantage of not giving off nitrous oxides, although the gases produced are still toxic.

Under the action of light, it shows a certain tendency towards acquiring a yellow tone, but in the normal conditions of use of motion picture films, this characteristic is not significant.

The degradation of the triacetate cannot be initiated spontaneously.

For triacetate to start degrading, external agents are necessary, capable of activating the reaction by means of oxidation mechanisms, ultraviolet photodegradation or by hydrolysis (under the combined effect of high temperatures and humidity).

The degradation by oxidation is inhibited by means of the addition of an antioxidant to the mass of the plastic. Under the conditions in which the motion picture films are used, ultraviolet radiation is not a major problem. Thus, it is necessary to place the susceptibility to water of the triacetate (between two and

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29 The research on the characteristics and preservation of the cellulose triacetate films performed by the Instituto de Polymers for the Filmoteca Española revealed another kind of difference, in principle unrelated to the chemical composition of the plastic supports, however, it is not likely that they will be inconsequential for the preservation of the films.
There are significant differences between the thicknesses of the films (both with respect to their supports as well as their emulsions) and these differences are detected between products of the same or different manufacturers. The study of samples manufactured between the fifties and the nineties reveal differences in the thickness of the supports which can amount to almost 10% and, significantly, also show how the average thickness of the films has gradually declined, decade after decade, to the point of being more than 4% less than in the fifties. (see: Textual Note IV)

30 In "Soportes cinematográficos basados en triacetato de celulosa" (see Note 11), F. Catalina points out that the plasticiser content in the Agfa film used for the tests performed in the Instituto de Polímeros, was as much as 10.79% of the total mass of the support.

three times greater than that of the nitrate) at the origin of acetic degradation, but at the same time stressing that this degradation will only come about if sufficiently high storage temperatures are also involved.[31]

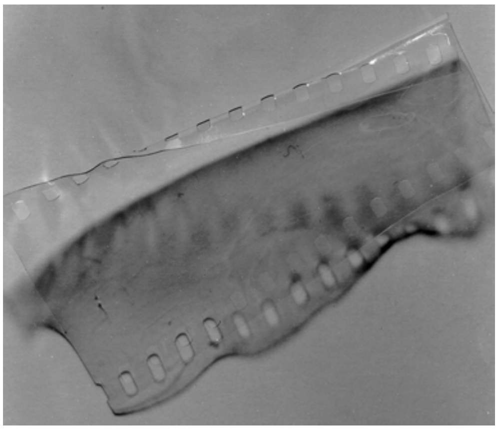
The fact that the structural degradation of these plastics, in contrast to that of the nitrates, cannot be initiated without the action of an external agent constitutes the basis for the possibility of developing preservation policies founded on the maintenance of triacetate supports.

Notwithstanding the foregoing, it is necessary to keep in mind that what depends on the action of external agents is the commencement of the degradation; once acetic degradation has begun and there is already free acetic acid in the plastic, the degradation becomes self-sustainable and the control of the storage conditions will only serve to slow down its progress.

J.M. Reilly points out that the degradation can begin during the manufacturing process of the acetate itself[32] and, in effect, the purification and esterification processes take place at relatively high temperatures (and some with the direct presence of water among the components), and the plastic characteristics (indispensable for shaping it into thin sheets) are achieved by raising the temperature. The acetic degradation can begin at such moments and arrive at an archive "latent" in an absolutely new film

As has been previously mentioned, there are different procedures for the manufacture of triacetate and, in addition, it is highly likely that each procedure will have been changed more than once on the production lines of each manufacturer. Perhaps, these irregularities, in concurrence with other causes, are at the source of the differences for successful preservation that have been observed between films from different manufacturers or eras.

Triphenyl phosphate is a plasticiser, which is much less volatile than the camphor used in the nitrates. For as long as the acetic degradation does not affect it, the contraction on account of the loss of plasticiser will stay at minimal levels (as can be observed in films from the fifties, without decay, which reveal very slight contractions) however, when the degradation develops, the plasticiser will also intervene in the reactions and its disappearance will contribute to the destruction of the film, increasing its rigidity and deforming it.

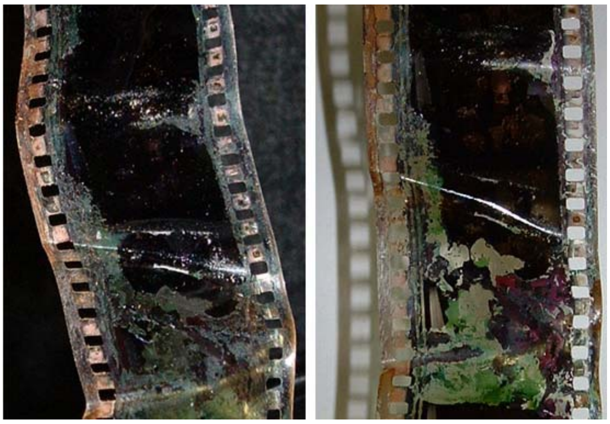


As can be seen in the illustration, which shows a sample of film from which all of the plasticiser has been extracted in a laboratory, the contraction (approximately 7.8% lengthwise) and the deformations and the rigidity have become extreme.

31 In the Filmoteca Española, films have been recovered that had been stored in cold yet extremely humid environments which appeared to be completely deteriorated by microbiological contamination (the fungus had gobbled up the films), and these films showed no evidence whatsoever of the vinegar syndrome.

32 Reilly, James M.: "Preservation of Acetate Base Motion Picture Film: Environmental Assessment and Cost Management". *In: The Vinegar Syndrome. Gamma Group - Association des Cinémathèque Européennes, Bologna, 2000.*

The structural degradation of the plastic material will lead to the loss of its mechanical properties, as well as to the appearance of volatile products such as CO, CO_2, water and acetic acid. If all of these products, on account of the films being kept in airtight containers or due to simple deficiencies in the ventilation of the storage areas, are not removed from the atmosphere surrounding the film, they will contribute to accelerating the progress of degradation.



F. 9: Film dampened by acetic acid

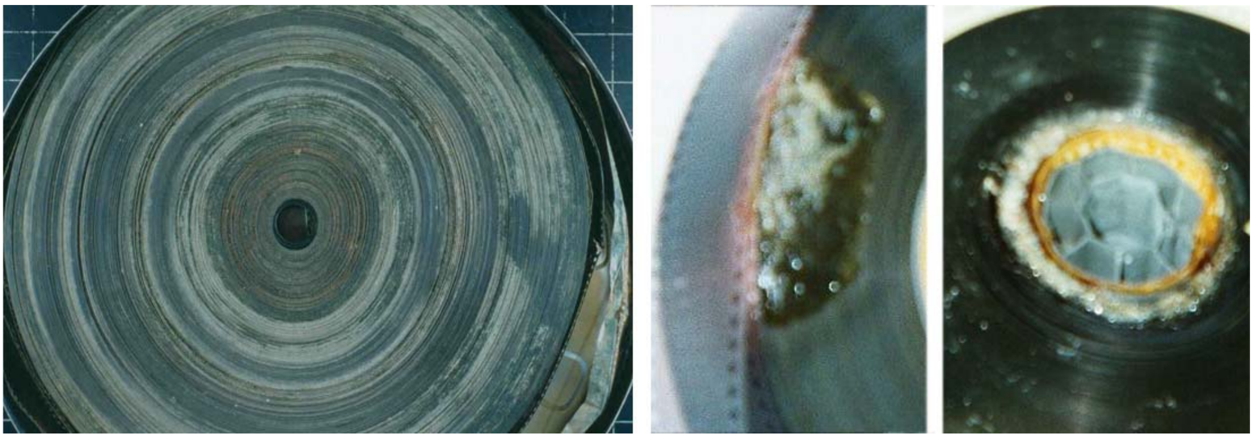
The same as occurs with the degradation of the nitrate, in the triacetates, the degradation begins without any perceptible alterations in the properties of the plastic.

Jean-Louis Bigourdan has established a detailed relationship between the perceptible symptoms and of the effects and damages produced by the structural degradation of the triacetates.[33]

Bigourdan points out that the increase in the acidity is the first detectable symptom of acetic degradation. In its early stages, the increase in the acidity is not directly perceptible; however it can be detected by means of laboratory analyses or by placing acidity detectors in direct contact with the film inside the containers proper.[34]

The vinegar odour (characteristic sign of the syndrome) is usually the first obviously noticeable sign of the degradation.

The acetic acid is responsible for the increase in the acidity and for the vinegar odour, and as the degradation progresses; both characteristics will continue to intensify to the extent that they may even become a health hazard for the archivists.



F. 10-11: Reels in the last stages of deterioration

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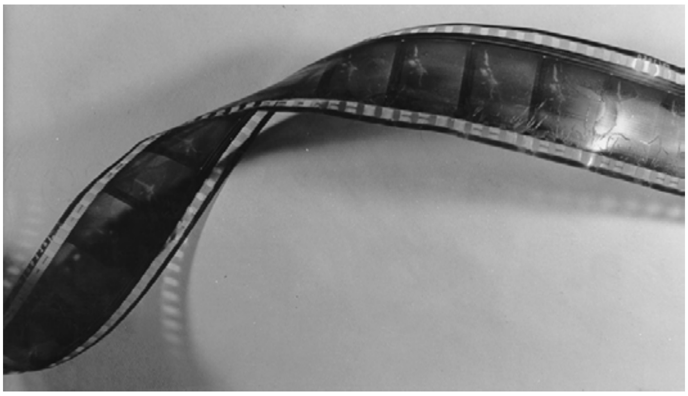
33 Bigourdan, Jean-Louis: "Preservation of Acetate Base Motion-Picture Film: From Stability Studies to Film Preservation in Practice". *In: The Vinegar Syndrome. Gamma Group - Association des Cinémathèque Européennes, Bologna, 2000. (see: Textual Note V)*

34 The characteristics and procedures for the use of these detectors are provided in Section 2 of this document.

The degradation and loss of the plasticiser are involved in the advance of the shrinkage. In these conditions the adhesion between support and emulsion is weakened, with the cracking and flaking of the emulsion and, as the process advances, the degraded plasticiser will migrate towards the surface of the film forming crystals and bubbles that can definitively destroy the transparency of the film.

The progress of structural degradation will deform the support and alter its mechanical characteristics. The support can become soft and dilate, enlarging its dimensions and becoming deformed, and will subsequently lose strength and volume and finally contract. In other processes (or in other stages of the same process) the supports become rigid and fragile, and the deformations, which will principally affect the perforation areas, can eventually render reproduction impossible, because the surface of the film is not sufficiently flat for proper placement in the printergate.



F. 12: Rigid film and distorted by deterioration

Marianne Winderickx has pointed out the relationship existing between the development of the acetic degradation and the “polishing” and varnishing treatments used for the "restoration" of physical injuries to negatives and prints[35]. This statement reinforces the importance of the relationship existing between the advance of the degradation and the lack of ventilation in the rolls of film. The varnishing and polishing hinders the release of the acetic gases and reinforces their activity on the inside of the films.

In the early stages of the acetic degradation, the gelatine of the emulsion, which is also affected by high temperatures and humidity, produces ammonium hydroxide, which aids in stabilising the support by neutralising the acetic acid[36]; however, as the process advances, the acetic acid (despite being a weak acid) will eventually damage the gelatines, softening them and even liquefying them.

1.42 - Synthetic Plastics [37]

On raising the question of the characteristics of the synthetic plastics, it is necessary to consider, first of all, that under each of the names accepted for these plastics, there are true families of materials, made up by tens or hundreds of different products, with very different and even opposing characteristics.

Moreover, it must be taken into account that in the manufacture of each precise type of material, there are many alternatives –insofar as the components that can be used in the mixtures, the purity of these components and the

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35 *Winderickx, Marianne: "Monitoring of the Collections and Prevention Methods at the Cinémathèque Royale de Belgique".* In: The Vinegar Syndrome. Gamma Group - Association des Cinémathèque Européennes, Bologna, 2000.

36 Catalina, Fernando: work referenced.

37 The data used in order to characterise these plastics are drawn, basically, from: *J.A. Buydson " Plastics Materials " 3rd revised edition.* Butterwooth Scientific - Instituto de Polímeros y Cauchos, London - Madrid, 1975.

systems of production --, alternatives that, undoubtedly, introduce significant differences for the possibilities of preserving the materials.

Thus, if on considering the characteristics of preservation of plastics derived from cellulose (for the manufacture of which, the process is initiated of the basis of a pre-existing structure: that of the fibres of the cellulose itself) it is necessary to take into consideration the variables that can arise from the manufacturing procedures, on considering the characteristics of preservation of synthetic plastics, it is essential to consider that their manufacture begins with that of the products that will form the structural chains of the polymer and, in these circumstances, supports that will be presented by manufacturers as made of substantively identical plastics may display very different forms of behaviour with respect to their preservation in the long term.

Among the synthetic plastics, the polyvinyl chlorides and the polyester and polycarbonate resins are those that have been used most widely in the manufacture of supports for cinematography and the audiovisual industry.

1.421 – Polyvinyl Chloride (PVC)
As from the fifties, materials of this group were used for the manufacture of phonographic discs and magnetic tapes for audio and video.

In principle, the polyvinyl chloride is a rigid, colourless material and quite unstable.

Temperatures above 70ºC are very harmful to its properties and, as a result, in its manufacture, it is necessary to add stabilisers that will make it possible to reach the temperatures necessary for moulding the material without causing its degradation.

The stabilisers are also necessary in order to preserve the material from its tendency towards oxidation and its weakness with respect to ultraviolet radiation.

In the polychlorides used in audiovisual supports, stabilising products based on lead and on tin are used with extremely satisfactory results.

Given that the PVC is a good electricity insulator, for its use in discs or tapes, it is necessary to introduce anti-static and lubricating additives into its composition that will prevent the accumulation of electrical charges and the adhesion between convolutions in the rolls of tape.

The PVC compounds are highly resistant to microbiological degradation.

At the end of the twenties, the first commercial polychlorides appeared on the market. These were combined polymers (copolymers) developed with a mixture of vinyl chloride and vinyl acetate. Starting in the fifties this type of copolymer was used in the manufacture of phonographic discs.

The copolymer of vinyl chloride and acetate is a plastic with very good characteristics of rigidity and elasticity, and its mechanical resistance and chemical stability –if kept in appropriate environmental conditions—are very high.

For the manufacture of magnetic tapes, unplasticised PVC is used (that is: one to which a plasticiser has not been added). The unplasticised PVCs are rigid, brittle materials but capable of being modified by means of the addition of products that improve their mechanical strength and their elasticity.

In the manufacture of tapes, stabilising additives (tin), impact modifiers, colour stabilisers, anti-static agents and lubricants are used.

The fabrication of products with unplasticised PVC is performed at temperatures at which the decomposition of the polymer is brought about; consequently, these processes are extremely delicate and must be carried out in absolutely controlled systems.

In the manufacture of tapes, a compacted mass of PVC passes through a hot rolling mill that stretches it lengthwise until forming film of the desired thickness. This laminating must be performed at high speed in order to control the degradation of the plastic.

The characteristics of resistance of the PVC tapes are far superior to those of triacetate (more than double in all of the parameters), enabling it to be used in thicknesses of 40, 25 and 15γm.

With the addition of pigments and colour stabilisers, its resistance to ultraviolet radiation and the other atmospheric agents is also much higher than that of triacetate.[38]

The significance of PVC in the audiovisual industry has declined enormously in the last two decades. The phonographic discs have been relegated to the past by the optical read CDs, and with respect to the magnetic tapes (despite the fact that PVC has the best characteristics for the adhesion of the resin agglutinating the magnetic particles) it has been replaced by polyester.

1.422 - Polyester Resins (Polyethylene Terephthalate - PET)

The polyesters constitute one of the most numerous families of synthetic polymers. Within this family, polyethylene terephthalate (PET) is an extremely important material in the fabrication of containers, fibres and film, and the only one that has been used for audiovisual supports.

Polyethylene terephthalate was discovered in 1941 by British chemists who were working on the development of polymers suitable for the manufacture of fibres. A few years later, procedures were discovered for the production of film with this plastic.

In the audiovisual industry, polyester tapes are used in the manufacture of sprocketed films, for photochemical and magnetic emulsions (with thicknesses of 110 and 40γm, respectively) and plain (unperforated) tapes for audio and video (with thicknesses of 40, 25 and 15 γm).

In the fabrication of thin films, the sheet, previously shaped and compacted by extrusion, is stretched in both directions (biaxial orientation) while subjected to temperatures close to 100ºC. Following stretching, the film is reheated in order to stabilise its crystallisation and enhance its dimensional stability.

The PET films have mechanical characteristics, which are far superior to those of the triacetate, with a tensile strength two to three times greater and a tear resistance that can be as much as ten times greater than that of theTAC.

Its low water permeability is also very important. Its resistance to degradation by microorganisms is superior to that of the cellulose plastics.

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38 The resistance of some unplasticised PVCs to atmospheric agents (light, oxygen, humidity and temperature) is so high that they have been widely applied as building materials (windows, pipes) in which this resistance is the determining factor.

Polyester films are not very soluble by the action of the more commonly used mineral solvent acids; as a result, in their cinematographic use, splicing should be performed by ultrasonic heat welding.

At normal room temperatures, its properties as an electrical insulant are very high and it has a strong tendency towards accumulating static electricity.

The glass transition temperature (crystallisation) of the PET is above 70ºC, and in a crystalline state, its melting point is around 260ºC.

All of the environmental parameters (light, oxygen, temperature and humidity) influence the degradation of the PET. The increase in the degradation up to sensitive levels is closely associated with the glass transition temperature of the plastic, with the mechanisms of hydrolysis being the principal channels of degradation, however, at temperatures below the aforementioned glass transition temperature, the degradation is very low and is related to the original degree of crystallisation of the material.

Studies on degradation and preservation[39] show major differences in the preservation predictions at room temperature, but coincide absolutely on marking the barrier that, for the preservation of the characteristics of the polymer, exists between one side and the other of its glass transition temperature.

Seventy degrees centigrade (70ºC) is not, of course, a temperature that can be reached in the storage areas of archives however, as was observed with respect to celluloid, it is indeed a temperature that can be reached inside the convolutions of a roll of film kept stored, by contracting and increasing the pressure of the wound convolutions- over many years.

The use of PET as the support for photochemical emulsions has made it necessary to solve problems relating to the adherence between the emulsion and support and with its tendency to accumulate static charges.

In the sixties, polyester was adopted for narrow gauge films (Super 8mm) and also began to be used for professional films; however, in these wide-gauge films, the static charges that accumulate in the rolls during their passage through the machinery may reach the point of stopping the polyester, halt the movement of the equipment; and this serious problem delayed the final industrial acceptance of the polyester supports. In order to solve the problem it was necessary to incorporate different anti-static and anti-adherent elements into the films. At the present time, the polyester supports for photochemical emulsions have reached a volume of use equal to or greater than that of the triacetate films.

For a number of years, in the sprocketed magnetic films used during the production of the sound tracks, the PVC, triacetate and polyester supports coexisted; however, as the static problems were gradually overcome, the polyester supports completely replaced the others.

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39 See: *Norman S. Allen, Michele Edge, Mehrdad Mohammadian and Ken Jones: "Physicochemical aspects of the environmental degradation of poly(ethylene terephthalate)".* In: Polymer Degradation and Stability 43 (1994) 229-237 Elsevier Science Publishers Ltd. London, U.K.

M. Edge, N. S. Allen, M. Hayes, T. S. Jewitt, K. Brems and V. Horie: "Degradation of magnetic tape: Support and binder stability". In: Polymer Degradation and Stability 39 (1993) 207-214 Elsevier Science Publishers Ltd. London U.K.

M. Edge, N. S. Allen, J. H. He, M. Derham and Y. Shinagawa: "Physical aspects of the thermal and hydrolytic ageing of polyester, polysulphone and polycarbonate films". In: Polymer Degradation and Stability 44 (1994) 193-200 Elsevier Science Publishers Ltd. London, U.K.

1.423 - Polycarbonate and Polyacrylic Resins

Although there is a wide range of polycarbonates, the only one that has undergone a significant commercial development is the bisphenol A polycarbonate.

In the audiovisual industry, this material is the main component of the optical discs for sound and images and is also used in the manufacture of a number of moving mechanical components in cameras and electronic equipment.

The bisphenol A polycarbonate is a typical example of the enormous variety of products that can be included under a single name and how, from the very moment of the preparation of the components of the polymer, the differences in the components selected, in their preparation and in the fabrication and moulding of the polymer, will influence its physical characteristics and its strength and stability.

The polycarbonate is a basically amorphous polymer with high crystallisation (145ºC) and melting (+ de 225ºC) temperatures.

Its principal mechanical properties are its rigidity and toughness, characteristics that it retains up to temperatures on the order of 140ºC.

These characteristics make it possible to manufacture optical discs, which with a thickness of only 1.2mm stay completely rigid and reveal very high impact strength.

This material is not very flammable and is practically self-extinguishing. If it is fabricated by controlling the purity of its components, it will be extremely transparent yet has a marked tendency towards yellowing.

In the study made by M. Edge and collaborators in Manchester (see note 41), in which ageing tests were made at 80ºC and at 96 and 0% relative humidity, the polycarbonate revealed degradations similar to those of the polyethylene terephthalate (PET).

However, in cinematography, the importance of these results can be quite different for the two plastics. In normal conditions of wear and tear of the polycarbonate, as a resistant substrate in optical disks, and on the basis of the standard conditions of preservation and storage, it is not possible to imagine how temperatures as high as 80ºC inside the optical discs could be reached.

The other plastic component of optical disks is a polyacrylic resin (commercially known as "methacrylate" or "Plexiglas"), characterised on account of possessing a transparency similar to that of glass and of being highly resistant to ultraviolet radiation.

These plastics have relatively little resistance to abrasion and, thus, can be scratched rather easily. In normal conditions of wear and tear of optical disks, this characteristic is not particularly significant.

2 – The Sensitive Layers

Looking solely at their fundamental characteristics, in the audiovisual medium, four different systems have been used to record moving images and sound[40] and, except for the systems belonging to the last of these groups, all carry what could be described as a "sensitive layer" on which the information is recorded.

Schematically defined, these four systems would be:

- The photochemical modification of crystals initially sensitive to light.
  Cinematography came into being and developed on the possibilities of this system, which was also the first truly functional system for the development of motion picture sound.
- The change of magnetic orientation of particles of oxides or ferromagnetic metals.
  Initially, this system was only used for sound, however, in the last three decades of the 20th century, the volume of images recorded or reproduced on ferromagnetic emulsions has grown enormously and is now much greater than that of the images recorded by the photochemical systems.
- The modification of the capacity of reflection of metal sheets.
  To a degree, the early photographic daguerreotypes could be ascribed to this system, however, only in the last few decades have optical discs begun to appear in which the surface of a reflective sheet is modified ("burned") in order to record the information directly by means of the differences in reflection.
- The impression of the information by means of moulding, embossing or imbibition.
  The Technicolor copies and phonograph or optical discs are the typical examples of these systems, which can only be used for making reproductions.

2.1- Photochemical Emulsions

In the classical technology of cinematography, images and sound are recorded inside one or several extremely thin layers of gelatine[41], which contain the photosensitive materials and different types of filters and products that contribute to the formation of the colour.

2.11 – Structure of the Sensitive Layer

The emulsions for black and white are made up by a single layer of silver halide, gelatine and may have another, very thin layer as a protective coating.

In the films for colour additive systems, the layer that reacts to the light is substantively identical to that of the black and white emulsions (and in many of these systems, black and white films are used directly) however, its position with respect to the support can vary, depending on the place the layer of filters

40 It would be possible to add a fifth system to these four: the modification of the electronic state in the "solid" devices of computers, which is completely outside of the scope of this study.

41 Although within a single film the thickness of the emulsion may be very homogeneous, between films of different types and even within the same type, in films of different brands or fabricated in different periods of time, the differences in thickness can be relatively very important. In black and white films, the thickness of the emulsions can range between 3 and 11 micra.

occupies (generally made up by gelatines as well) and the form in which the film is to be positioned in the camera.

For the colour subtractive systems, emulsions have been used with several different arrangements and composition of layers. In the systems based on separation negatives in black and white, in order to obtain prints, the range of possibilities have gone from films with a simple layer of gelatine (not sensitive to light, without any silver bromide) designed to receive the colours of the image by imbibition, to standard film for black and white or film with both surfaces coated with an emulsion (duplitized). In the reversal systems for colour and in those of negatives and positives for colour, the structure of the emulsion consists of at least five layers: one exterior layer of protection, one filter layer and three layers of colour.

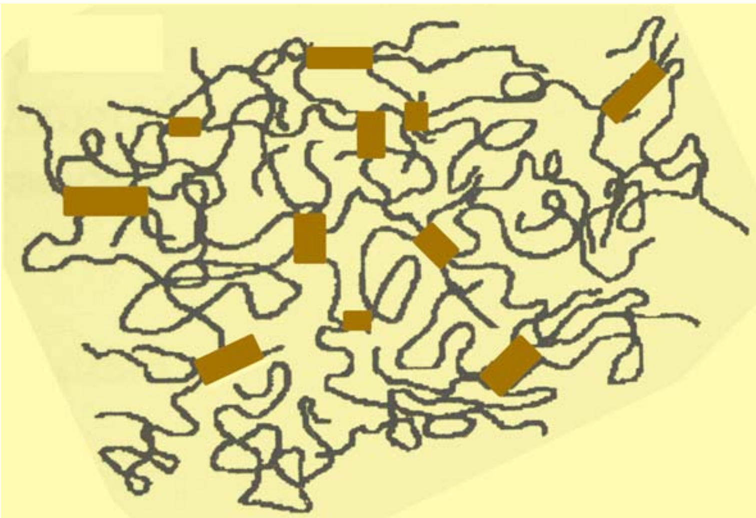
In order to achieve the bond between emulsion and support, a layer called " adherent substrate" is introduced in all films.

2.12 - Gelatines[42]

Around the middle of the 19th century, tests were initiated in order to use a layer of gelatine as the "container" for the photosensitive substances. In 1871, a British physician, R.L. Maddox, prepared silver bromide-gelatine transparency plates. In a matter of a few years, with procedures similar to those used by Maddox, plates were prepared for negatives and paper for positives, and the silver bromide-gelatine base emulsions completely replaced those prepared with collodion that had made the first "instant" photographs possible.

The gelatine base emulsions were definitely better than any other used up to that time. Barely six years after Maddox's work, it was noted that with these emulsions, speeds ten times faster than in those prepared with collodion were attained, and it was said that the gelatine itself appeared to play an important role in this increase in sensitivity.

Gelatines are polypeptides with a high molecular weight that have been used for thousands of years as glue. They are obtained from collagens extracted from animal skins and bones.



F. 13: Diagram of the amorphous structure of the gelatine's molecular chain with rigid unions of collagen type.
(Image given by Concepción Abrusci)

The gelatines used in photography are those of the highest quality and their preparation requires an enormous amount of tests and controls; controls that

42 Basically, in the preparation of this section, reference was made to the (unpublished) work : *"Biodegradación de las películas cinematográficas: soportes celulósicos y gelatinas"*, prepared by *Concepción Abrusci* for the Filmoteca Española.

begin from the time the cattle are selected for the extraction of the collagen from their skins and bones. The systems of control used have succeeded in providing a high degree of uniformity to the characteristics of photographic gelatines and an extremely low presence of contaminating elements that could alter their properties or those of the photosensitive halides.
For cinematography, which requires the use of long strips of flexible film, the mechanical characteristics of the gelatines were indispensable; given that they made it possible to obtain very thin (less than one micron) and flexible viscous coatings, with sufficient strength to enable them to be coated on the supports. The gelatines have a relatively high degree of resistance to abrasion.

In addition, the gelatines are eminently suited for acting as containers of an enormous variety of elements, ranging from silver crystals to multiple solutions of dyes and other products, indispensable in photographic chemistry.

Their optical characteristics are also very important. The extremely pure gelatines are very transparent and almost lack the tendency towards yellowing. Moreover, their index of refraction (1.54) is close to that of the plastic of the support.

The contribution of the gelatine to the sensitivity of the photographic emulsions stems from the fact that, during the preparation of the emulsion, it controls the speed of growth of the halide crystals and prevents their agglomeration and sedimentation.

The gelatine swells during the processing, absorbing the liquids from the baths and enabling the chemical reactions to take place inside it.

It is a very stable material (in fact, as stable or even more so that the supports) and the environmental conditions necessary in order to achieve optimal preservation are not overly demanding; nevertheless, if the film is kept for a long period at a temperature above 40ºC, its mechanical characteristics can be altered. At high temperatures, between 80 and 100ºC, the gelatines will deteriorate in a matter of minutes.

The moisture content of the gelatines is relatively high, representing between 9 and 15% of their total weight.

They have a very high capacity for absorbing (and for giving off) moisture, to the extent of being able to absorb several times their own weight of cold water.

The combination between this tendency of the gelatines to absorb or give off moisture and the variations in humidity and temperature in storage facilities can seriously deteriorate and even destroy the physical characteristics of the photographic emulsions (See Section 2.4).

High humidity and temperatures, in combination with poorly ventilated storage facilities, favour the development of the gelatine emulsions' number one enemy: the microorganisms, for many of which the gelatines are a food and a real "culture broth".

The microorganisms are always present in the environment. Nieves Valentín, in a study made on Spanish museums and archives[43], identified colonies of microorganisms belonging to five major families of bacteria and six major families of fungi.

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43 *Valentín, N.: "Assessment of biodeterioration process in organic materials. Control methods"*. International Conference on Conservation and Restoration for Archive and Library Materials, Erice, 22-29 April 1996.

There is no possibility whatsoever of doing away with the microorganisms capable of growing on film for good. Any film can be decontaminated, but unless it is placed inside a hermetically-sealed sterile bag immediately right inside the decontamination chamber, it will begin to collect enough microorganisms within just a very few minutes for it to be possible- if the humidity, temperature and lack of ventilation were to favour their growth - for colonies to completely cover the entire film in very few days' time.

Photographic gelatines are a very expensive product, but have turned out to be an irreplaceable material in photography. The attempts to replace them with more economical materials have not succeeded, and only in some emulsions for special films (for example, those to be used under very high temperatures) have been replaced by synthetic polymers (resins).

2.13 – Preparation of the Emulsions

The researchers who invented and perfected photography discovered that the silver salts (chlorides, iodides, bromides) became blackened much more readily than the metal plate.

Chlorine, bromine and iodine have been used as sensitisers, although the bromine is the one that has been most successful and significant. From before the commencement of cinematography, a combination of bromine, as a fundamental halogen, with small amounts of iodine, was the mixture constantly used for the preparation of silver salts.

Although the industry has used and still uses many different systems for fabricating its emulsions and although, of course, the preparation of an emulsion for colour is much more complex, schematically, the preparation process for the emulsions can be described in four stages:

- The silver metal is converted into silver nitrate.
- The gelatine, in a liquid state, is mixed with the appropriate amounts of bromine and iodine.
  Other elements are also included that favour the halogenation process or the spectral sensitivity of the crystals and, if appropriate, the components that will gat involved in the formation of the colours.
- Mixture of the silver nitrate with the gelatine.
  The silver iodine-bromine is formed and, while the mixture is kept at an even temperature, a "maturing" process of the halide crystals takes place, whereby they increase in size ("grow"). During this period, more pure gelatine is often added to the mixture.
- The mass is washed in order to remove the residues of nitric acid and the remaining auxiliary components of the preparation, and is dried, ready for whatever operations as may be required prior to its spreading on the supports.

2.14 - Black and White Images

All of the photographic emulsions used in cinematography operate on the basis of the property of the silver (and of other metals) to blacken under the action of light, a property that has been known since ancient times.

Starting from this principle, all of the images that can be obtained by means of photochemical technology are –or at least initially are-- in black and white.[44]

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44 At least half of all of the efforts made to develop the photographic reproduction of colors has

The reaction to light by the silver halide crystals can only produce black and white images, however, in addition, these images will only correspond to the light pertaining to the more energetic zones of the light spectrum.

In 1801, J.W. Ritter discovered that silver blackened quicker under the action of violet and blue lights than under any other zone of the spectrum and, moreover, he noted that beyond the visible spectrum, beyond the violet, the blackening occurred at a greater speed and that, simultaneously, the yellow and red zones of the spectrum practically did not blacken at all.

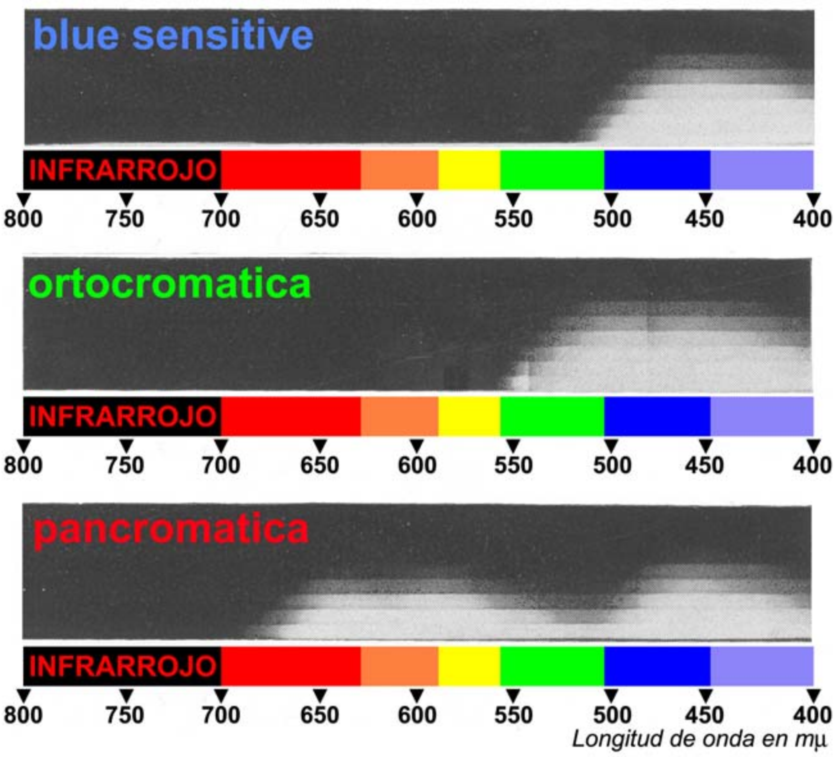
In 1873, H.W. Vogel pointed to the possibility of binding to the silver salts other substances sensitive to the other radiations of the spectrum, which would communicate this characteristic to the silver. Years later, the development of these substances –the chromatic sensitisers—made it possible to create emulsions sensitive to all of the regions of the light spectrum, including the depths of the infrared.

In line with their chromatic sensitivity, the black and white emulsions are classified as:

- Blue sensitive: sensitive only as far as blue.
- Orthochromatic: sensitive as far as the radiation of green light.
- Panchromatic: sensitive to the entire visible spectrum.

There are also special emulsions, sensitive to infrared radiations with wavelengths even greater than 1, / 000nm.

Naturally, creating films suitable for reproducing colours only became possible when emulsions with panchromatic sensitisation became available.



F. 14: Chromatic sensivity (Ilustration prepared with a catalogue Agfa of 1930)

In the early history of cinematographic photography, the possibility of filming the light corresponding to all of the colours exercised an enormous aesthetic influence and, consequently, a classification of the kind set out above represents the basic level of classification for the black and white films.

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been devoted to converting these black and white images into color images.

The panchromatic emulsions for negatives began to appear in motion pictures during the second decade of the 20th century, but it was not until 1922 when they began to spread throughout the industry.

Although panchromatic emulsions are also manufactured for duplication and for prints, the blue-sensitive and orthochromatic films have continued to be used for obtaining positive duplicates and prints in black and white, as well as for sound negatives until recently.

2.141 - Sensitivity and Characteristics of Reproduction

Cinematography is an art based on reproduction: the exterior reality is filmed (reproduced) on the films that are used in the camera and, in its turn, the films from the cameras will be reproduced on other films until obtaining the prints for exhibition.

In photochemical cinematography, after developing, the bright lights of the exterior will have formed black silver images and the dark areas will correspond to transparent areas in the film.

This inversion of the light into darkness and of darkness into transparency is known as negative image.

The negative image cannot be accepted as a reproduction of reality, and photography developed two ways for solving this problem: the reversal system and the negative→positive system.

2.141.1 – Reversal system

In the inversal or reversal treatment, the negative image is developed and bleached and the film is subjected to a further exposure (or to another chemical treatment), which affects the entire surface of the frame equally. This second exposure acts on all of the silver crystals that were not affected in the first exposure, the ones affected during filming. Developed once again, the image obtained will be exactly the reverse of the first one and, thus, will coincide with the exterior reality filmed.[45]

The reversal films have been very important in the history of the development of motion pictures in colour (See Sections 2.152), however, in black and white they have practically failed to emerge from the semi-professional and family environments.

2.141.2 - Negative→Positive System

Although reversal emulsions have been developed for the reproduction of duplicates and prints, the industrial process of motion picture films, which depends on the production of many prints (including hundreds or thousands), could only be developed with the system of negatives and positives on different supports.

In the negative→positive system, the negative becomes the "exterior reality" that is photographed (in the printer) on a fresh film. The process of inversion of bright and dark areas is repeated in this new reproduction, which, thus, will achieve an image with characteristics of light that will correspond exactly to those of the original and authentic exterior reality.

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45 The emulsions created for reversal can be used (by fixing and washing following development) as films for negative.
When using the edge marks to identify the generational level of the reproductions, it is necessary to take this possibility into account.

2.141.3 – Speed (Sensitivity)

The speed with which each emulsion reacts to light (speed at which sensitivity is defined) depends upon how "accessible" its halide crystals are to the impact of the photons. The larger the photons, the easier the light will reach the crystals.[46] This is an invariable principle in the emulsions, and although systems have been developed in order to organise the arrangement of the crystals so that they will present themselves reticulately "facing" the light, the emulsions with larger-size crystals are always the fastest.

The speed of the emulsions is a determining factor in the qualities of camera films.

In the course of filming, the maintenance of the control over the lighting conditions can require major financial investment or may even be completely impossible; in such a situation, having fast emulsions available may be essential.

On the contrary, the conditions in which the exposure takes places during reproduction are easy to control. Making duplicates and prints, the exposure conditions can be selected, and the determining factor of the quality of these emulsions is not their sensitivity, but rather the dimensions and structure of their silver crystals, on which the resolution, which can be achieved, will depend.

2.141.4 – Latent image

No matter how large the silver crystals may be, the image filmed and unprocessed is invisible (latent image). The visible image will be formed during developing of the film in the laboratory.

Those crystals, which in one or several of their thousands of molecules were directly hit by a photon during exposure, will take part in the formation of the latent image. Each one of the molecules hit will darken due to the effect of the light, but the crystal as whole will remain inert.

During the developing process, those crystals that "possess" molecules struck by light will react in the developing process by losing their status as halides and becoming transformed into black (opaque) crystals, capable of forming visible images.

And, even though the characteristics of the image depend initially on those of the emulsion and on the conditions in which the filming was performed, it will be in the developing process (during which it is possible to modify, "force", the effective sensitivity of the film) where the image will acquire the values of density, graininess, contrast and resolution that will define its qualities.

2.141.5 – Grain and graininess

In an "ideal" emulsion that would only have one layer of silver crystals, and following an extremely careful development, the image would be clearly made up by the crystals that received the light and the resolution achieved in the fine details (for example, in the reproduction of a weft of fine, extremely close lines) it would only be limited by the quality of the lenses used in filming and by the

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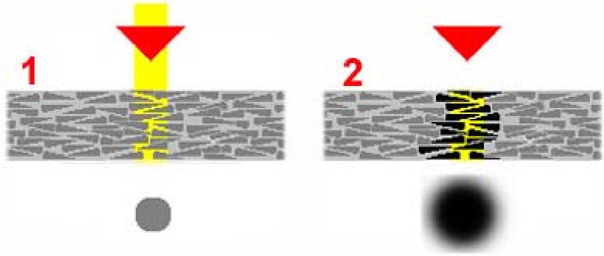
46 The sensitivity or speed is expressed by means of a numerical value (also called "sensitivity"), which indicates the reaction speed of an emulsion submitted to the action of light. These numerical values are established in experimentally controlled light exposures, and there exist various standardised systems (EI, ASA, DIN, BS) for determining and expressing the sensitivity of a film.
In order to evaluate the qualities of an emulsion, and together with its sensitivity, it is necessary to consider the regularity (arrangement and range of variation in size) of the silver crystals. The contribution of the gelatines to the sensitivity of the emulsions acts on these two aspects: it favours the growth of the crystals (maturing) and controls this growth by regulating the sizes attained.

crystal size itself. However, emulsions are not made up by a single layer of crystals, but rather by many superimposed layers and, moreover, the light is dispersed inside the emulsion affecting crystals not situated in the original direction of the light rays.

It is at this point where the size of the crystals forming the silver image begins to be decisive in order to define its qualities. The crystals affected by the light through the entire thickness of the emulsion will go on to form completely opaque points, the size of which will depend on the size of the silver crystals, the dispersion of the light through the emulsion and the conditions in which the developing process was done.



F. 15: As coming through the emulsion [1] the light acts over all the crystals it touchs. After the processing, these crystals will form an opaque point of greatest area than the one of the original ray of light [2], surrounded by a diffuse outline.

Even though questions about film processing are not treated in this book, it can be said primarily that the larger the size of the crystals, the brighter will be the photographed lights, and that the quicker and more chemically violent the development of the film, the larger will be the size of the agglomerations of crystals produced in the emulsion.

These agglomerations (known as "grain") could become visible on the screen during projection, appearing as aureoles of darkness surrounding the denser areas of the image (saturation) or like a weft of mobile and irregular dots, in the medium and low densities (graininess).

2.142 – Duplication Emulsions

The characteristics of the industrial development of motion picture films, which requires a large number of prints and the exporting of prints to different countries or geographical areas for their commercialisation, made it necessary to develop systems that would make it possible to obtain hundreds and even thousands of prints of each film and, as the first motion picture production firms were soon to learn, the number of prints that can be obtained from a negative is relatively low.

Including in the conditions in which the copying was performed at the beginning of the 19th century (films a few metres long, in slow and mechanically very simple printers), for the more successful films, the negatives were unable to withstand the making of all of the prints that were needed. To solve this problem, there were two possibilities: to film the same "subject" over again, making a new motion picture (a system that was used on many occasions); or obtain a fresh negative by reproducing a print.

In principle, the negative→positive reproduction can be repeated indefinitely. A positive print can be used as the original "exterior reality" for a new reproduction, thus obtaining a negative print from which new positive ones can be reproduced. In reality, the photographic quality that can be obtained declines with each new generation of reproductions.

The emulsions for black and white (including some special colour emulsions) can be used for either negatives or positives, and this what occurred during the early years of cinematography; however, the dimensions of the silver crystals (which determine the sensitivity primarily) can jeopardise the photographic quality obtainable. Naturally, in these conditions and as can be observed in the attached illustrations, a fourth-generation print will have an observable grain size, almost in plain view on the frame.

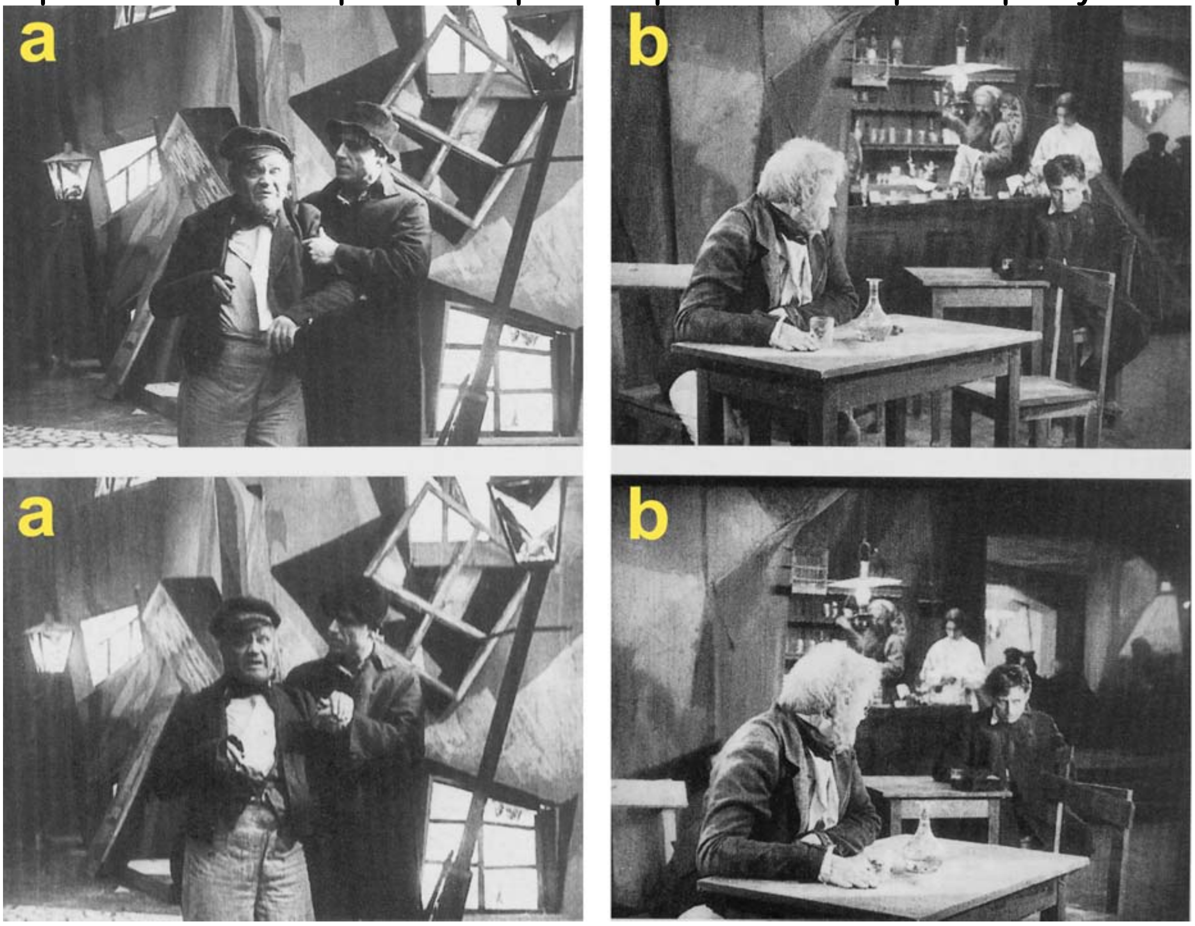
F. 17. (Image obtained by Irela Núñez)

Around 1905[47], emulsions appeared for prints, which were not as fast but with which it was possible to obtain better quality reproductions. However, for the needs of the motion picture trade, which required several negatives suitable for making top quality prints, the quality that could be obtained by using copy film for duplication purposes was not sufficient.

For many years, in the productions designed for cinema release, it was necessary to have a number of negatives available (obtained by using several

47 Kodak's "Regular Positive" was launched commercially in 1908.

cameras for each take or by filming several takes of each shot) that could be exported and make it possible to produce prints of the required quality.[48]



F. 18: Double negatives
[a] Shooting of two successive shots. [b] Simultaneous shooting with two cameras.
(Illustrations taken from : Mark-Paul Meyer "La restauración de Raskolnikof", en: "Archivos de la Filmoteca", nº 25-26. F.G.V.)

Around the mid twenties, manufacturers began to offer fine-grain films that were processed in special conditions and were especially designed for obtaining positive duplicates and/or negatives that would make it possible to make prints with characteristics similar to those reproduced from the negative.

The system that became finally established for the release printing of the films can be described through the four steps set out below:[49]

1. The motion picture is photographed on negative film with emulsions with the sensitivity appropriate to the lighting needs/possibilities of each scene. The negative film must be developed at a suitable contrast Gamma (for example: 0.6).
   Once the editing of the film and of the Original Negative has concluded, the grading is performed and the necessary prints are obtained until the desired qualities and continuity of light are achieved. These prints must be developed at the appropriate Gamma (for example: 2.5) in order to obtain the contrast

48 This practice was widely extended in silent films and was maintained in some of the early sound pictures. A particular case, that of the *Faust* filmed in 1925 by Murnau, is minutely examined by L. Berriatúa in the documentary "*Los cinco Faustos de Murnau*", produced by the Filmoteca Española in 1998.

49 There are many methods of duplication, using emulsions and processes different from the ones referred to here, which correspond to a standard process with modern materials.
The values given as an example have been taken from: *The Gamma Group: "Film Archives on Line".*

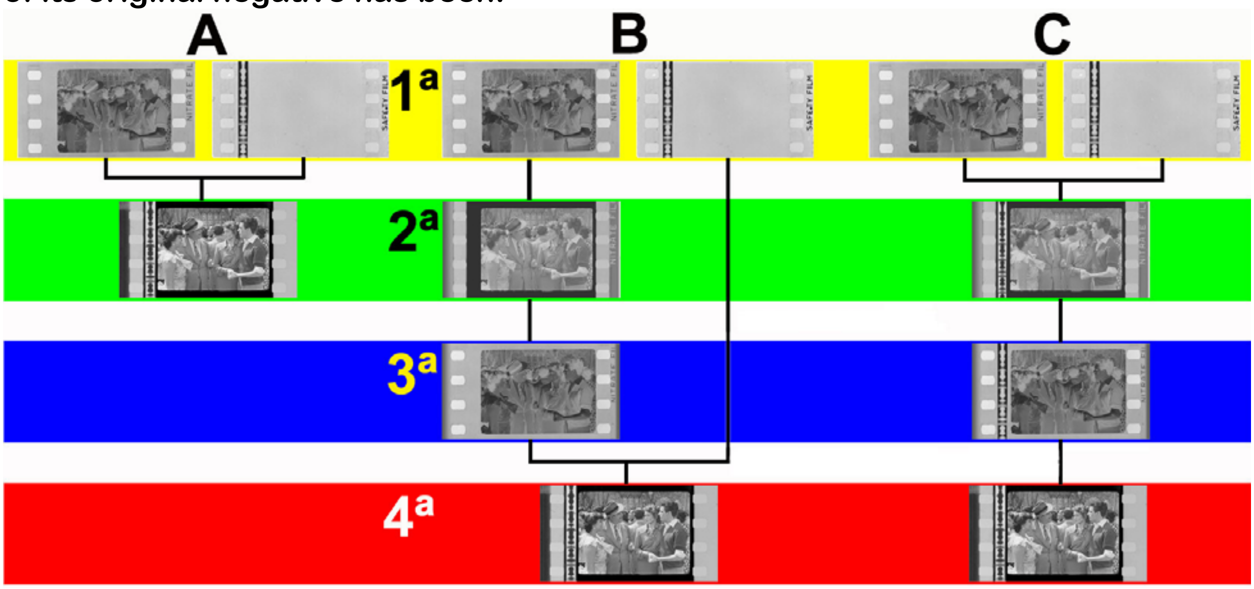
values of around 1.5, which, subjectively, are considered valid for the projection (0.6 contrast in the negative by 2.5 contrast in the print = 1.5)

2. Based on the criteria set out for the grading in the initial prints, a positive duplicate is obtained on a special very fine-grain emulsion, which is processed at a low Gamma (if working in B/W, for example, at 0.67).
   The image thus obtained will be a photographically grey image, "boring" with the light areas not being very transparent and blacks that are not very dense.
3. From the graded positive Duplicate, a further duplicate is made, a negative this time, which is processed with a high Gamma value (in the following example, at .15)
4. The projection prints are obtained from the Duplicate negative, developing the film with the same Gamma value as that used for the prints obtained from the negative.
   Thus, by working with the appropriate emulsions and processes, it is possible to obtain good photographic qualities and the same contrast value in the fourth-generation prints as in those of the second. (In the example presented: $0.6 \times 0.67 \times 1.5 \times 2.5 = 1.5$)

The use of duplicates solved the deterioration caused by wear and tear in the original negatives almost completely and has significant additional advantages in the production of prints. Moreover, the positive duplicates which can solely be used for making duplicate negatives, have some extremely important advantages to offer which make them the best preservation material: they are obtained roll by roll on a single type of emulsion, do not have the splices of the negative and contain the information of the original grading.

However, the duplicate system is not a cultural preservation system. The extent to which it was implemented depended upon the industrial characteristics of each cinematography, upon each individual studio and even upon the circumstances under which each motion picture was produced.

Only those companies and productions that expected to release many prints in different geographical areas implemented this system fully; in films that had only a small release or in productions with a low budget, the original negatives continued to be used for the striking of prints. Thus, paradoxically, in many situations, the more successful the motion picture, the worse the conservation of its original negative has been.



F. 19: Ways of duplication:
A – Direct duplication. Second generation print. B – Image duplicates. Combined print of fourth generation. C – Combined duplicates. Combined print of fourth generation (black and white)

2.143 – Conservation of the Silver Image

The blackening effect sustained by the silver under the action of light has been known since ancient times. Throughout the 18th century, different procedures were tried in order to be able to “draw with light” which, in some cases, attempted to capture images obtained in a dark chamber. The system was seen to be actually possible, however, the image obtained after extremely long exposures was not stable: the effect of the light continued to blacken the silver completely until the image faded into black.

The invention of photography is directly related to the procedures that made it possible to halt the blackening of the silver, thus “fixing” the image.[50]

In the photographic procedure used by cinematography, the film, after the development bath that converts the silver bromide crystals that were affected by the light into metallic silver, is submerged in a second bath, in which products are used, which dissolve all of the silver bromide crystals that have not been converted into metallic silver. This second bath will fix the image obtained; preventing it from continuing to blacken any further even through it may receive more light.

The fixing bath transforms the silver halide crystals not used in the formation of the image, into silver salts soluble in water that will be removed from the emulsion by means of a third bath, for rinsing.

The fixing agent most frequently used is sodium thiosulphate, often called "hypo" because in the early stages of photography it was, incorrectly, call sodium hyposulphate.

The metallic silver that remains in the emulsion following the fixing bath is a good conservation material.

Silver is a heavy metal, stable and with a relatively low inclination towards combining with other elements. The oxidation and the action exerted by light bring about surface reactions that are perceived as a blackening of the metal but, in the condition in which the silver is found when it is in a properly processed emulsion, these characteristics are unimportant, however, the residues of the fixing bath and those of the complex salts (silver thiosulphates), formed when the silver bromide is dissolved, can affect the image.

The remains of the soluble salt and fixer complexes must be removed from the film as quickly and completely as possible and, if they are not eliminated or efficient residues remain, the image will lose some qualities and may even fade completely in the end.

In order to eliminate these residues, following the fixing process, the film must be washed, as long and as intensely as necessary, to ensure that the remaining fixer residues and the soluble silver salts are minimal.

When an efficient rinse is achieved, it reduces the residues of the processing to amounts below the level necessary in order to affect the stability of the image, and the silver image will be an extremely stable record, which will fully meet the requirements defined for the preservation of cultural property.

The tendency to swell and absorb moisture of the gelatines, which is absolutely necessary during development and fixing, following the processing, becomes a permanent problem for the stability of the emulsion. To lessen this tendency,

50 In this section texts taken from: *The Gamma Group: "Film Archives on Line"* are used extensively.

many fixed solutions incorporate a hardener (hardening agent) which contributes to the stability of the emulsion, provides a certain degree of protection against scratches and damage due to use.

2.15 - Systems and Emulsions for Colour

The cinema never wanted to be in black and white. Although the beauty of the images achieved in black and white may captivate us, the reality is that they arose because with the technical conditions available it was not possible to obtain true reproductions of the “exterior” colours. Without a doubt, if the reproduction of colour were to have been possible from the very start of cinematography, we would not have experienced motion pictures in black and white, or we would have known them only as experimental tests.

Hubertus Pietrzok, in his contribution to the work "Preservation and restoration of moving images and sound"[51], describes three levels of difficulty for the reproduction of colour; these levels are related to the practical impossibility of achieving a balanced reproduction of all of the colours by means of systems of analysis based solely on the three primary colours, with the characteristics inherent to the devices and elements used for the analysis and the synthesis of the colours and, finally, although Pietrzok mentions it in the first place, with the limitations inherent to the dyes available for the elaboration of the image reproduced.

Throughout the first fifty years of its history, cinematography devoted more effort to introducing colour in films and to succeeding in obtaining “natural” colours than to any other technical imatter. Reproducing the natural colours in all of their richness continues to be a basic objective for image technology and, possibly will be an unattainable goal.

2.151 –Coloured Prints[52]

During the silent period, three basic procedures were developed for colouring the prints. The first two worked with the colour without associating it with the photographic process, while in the third, the areas with images were those on which the colour was applied.

- Direct colouring of selected areas in the frame.
- Tinting of the film.
- Chemical colouring of the image (toning)

Although there were specific developments for motion pictures, all of the systems came from those used for the dyeing of photographic prints. Each system had a number of versions -in many cases the work of an artisan rather than an industrial process, and often combinations of two systems were applied, obtaining images that were not realistic but that were immensely beautiful.

In all of these systems, the colour was introduced into the prints, obtained from negatives filmed in black and white.

Although occasionally, and principally in news reports and documentaries, the entire film could be tinted with the same colour, or the colour could be used with very low densities in order to tone up the image, the colours introduced in the prints became extremely important in cinematographic language, helping,

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51 Dr. Hubertus Pietrzok: "Historical development and properties of the colour photographic material used in cine matography". *In: "Preservation and restoration of moving images and sound" - Chapter 4, pp.:19 to 59. FIAF, Brussels, 1986.* (See also: Textual Note VII)

52 In this section texts taken from *The Gamma Group: "Film Archives on Line"* are used extensively.

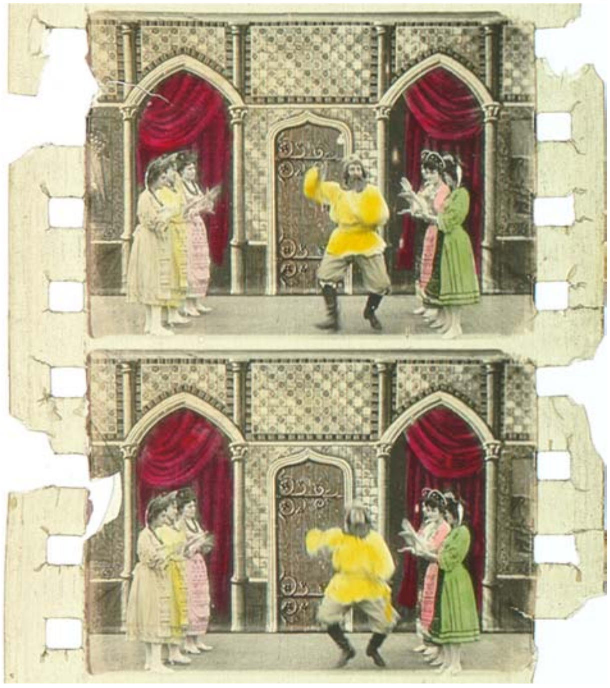
for example, to identify the night scenes by means of a blue tone, or to underline violent scenes with red.[53]

2.151.1 – Direct Colouring of Selected Areas

In these systems each frame could be tinted with one or several different colours (there are examples with as many as six colours) on selected areas, in order to make certain images or parts of the frame stand out. The tinted surfaces were repeated in all of the frames of the shot, changing position and shape in line with the variations in the photographic image.

The systems used for spreading the colours were developed in an attempt to achieve a sharper outline of the image areas selected and to facilitate the exact repetition of the colouring in successive frames.

In the early films, the tinting was performed directly with a paintbrush, colouring (with water or alcohol anilines) the area to be illuminated in each frame.



The inevitable deficiencies of the manual system led to the introduction of templates, cut in the shape of the surface to be covered with each of the colours, which were placed "on register" on each frame, and the colour was spread by means of a “polishing bag”.

F. 21: Tinting with stencils
(image obtained from a reproduction on emulsion for colour)

53 In his analysis of the original French negative of *"Au-delà de la mort" (Benito Pered, 1927)*, Luciano Berriatúa found an instruction to introduce one single frame tinted in red so that it would heighten the flash of a shot that was fired.

These colouring systems by templates --stencilling—introduced a degree of mechanisation into the procedure and an industrial standard was achieved in the "Pathécolor" system, in which the templates were cut on a strip of film, by means of a cutter placed in a pantograph, the pointer of which following an enlargement of the frame. In this system, the films were dyed colour by colour, and the aniline dyes were spread with a roller.

The results obtained by the Pathécolor system are of an astonishing precision, however, even in the most highly perfected system, the boundaries of the colour stains do not coincide exactly in two successive frames.

F. 22: Pathécolor

The tremendous amount of work involved in these systems made each print much more expensive. Therefore, up until the distribution system by rental of the prints became widely used, producers normally offered, simultaneously, coloured prints and prints in black and white (less expensive) of all of their films.

2.151.2 - Tinting

The tinting of the entire surface of the film was the first and, without a doubt, the system most widely used. In fact, this system was used from the earliest years and was applied to the majority of the motion pictures produced during the silent period and, on many occasions; it was combined with selective colourings or with tonings. There were two basic procedures for the tinting of the films.

F. 23: Tintings
Yellow, rose, amber and blue in a spanish print of an italian production.

F. 24: Double tintings
Blue tinting + Rose toning. Rose tinting + Brown toning. Lavender tinting + Rose toning.

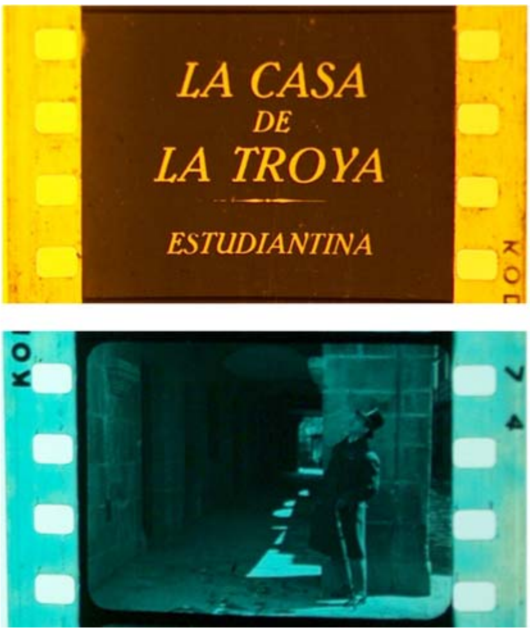
First, “varnishing” systems were used, by spreading the dyes on the surface of the support.

Initially, in this system the varnish (an alcoholic aniline) was spread on the completely processed film by means of a roller. However, this type of post-tinting system caused a number of problems in the distribution of the dye and was not very successful.

Around 1920, the film manufacturers began to include in their sales catalogues films for prints with a pre-tinted support. These films were very well received and, although they did not manage to completely replace the tinting performed in laboratories, their manufacture continued even after 1930. The pre-tinted prints offered a high level of evenness of colour in each roll, although in rolls from different manufacturing lots (or, of course, fabricated in different years or by different companies), there were significant differences in shades.

F. 25: Pre-tinted films for sound prints.
Blue, lavender, green, yellow, amber and rose pre-tintings from the Agfa catalogue: “Positiv-Film / Farbige Unterlage für Tonfilm- Zwecke Positive Film / Tinted base for Sound Films”. Wolfen, 1929

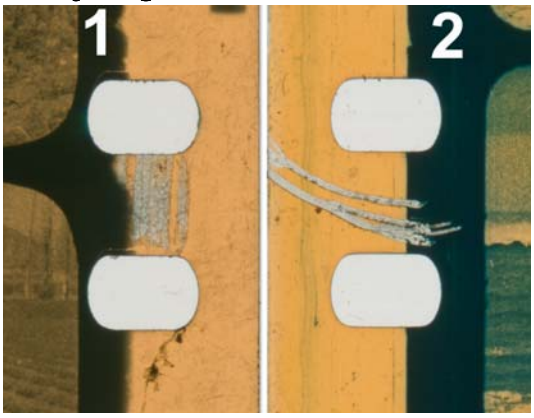
In the second procedure, the fully processed prints were submerged in a bath of anilines dissolved in water. The majority of laboratories set up tinting installations, which were still used even after all manufacturers offered pre-tinted stock in their catalogues, given that the quality
obtained in these post-dyeing systems was comparable to that of the pre-tinted supports offered by the film manufacturers.



F. 26: Laboratory tintings and tonings
Tinted title and toned (which can be observed in the color of the manufacturer mark) and night scene tinted in blue.

Identifying these systems is relatively easy.

- The films are tinted throughout their entire surface[54], including the edge nerves and between sprocket holes.
- The transparent areas show the colour of the dyeing, and in the densities, the colour of the dye is mixed with the black of the image in such a way that we can see colour shadows; of course, the totally opaque areas continue to be black when projected.
- Moreover, in the films varnished on the support, a scratch in the image area will eliminate the colour but not the image, however, in films where the gelatine is dyed; a scratch on the emulsion will damage both the colour as well as the image.



F. 27: [1] Film tinted on the side of the support. [2] Film with the gelatine tinted by soaking.

2.151.3 – Toning of the Image

In the chemical toning systems, the photographic image, with its own shapes and densities, is what is coloured by means of the replacement of the black silver by a dye.

In toned films, the transparent areas continue to be transparent and do not pick up any colour whatsoever, while the image acquires the colour of the dye used with densities that will depend on those of the original silver image.

Two basic systems were used: metallic toning and toning with a fixative.

In the metallic toning, the silver of the image is replaced by other metallic salts (gold, copper, uranium, etc.), which can be chemically bonded to the silver and have good chemical stability characteristics. Although this type of toning provided colours of a good intensity, there are few metallic salts that can replace silver, and the catalogue of colours was limited.

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54 In "*Film Archives on Line*", information is give on lacquering systems (dyeing with a solvent that evaporates quickly leaving only the dye), which were used only on the surface between the perforated tracks.

The second technique, toning with a fixative, made it possible to use organic dyes that offered a much wider range of colours (practically unlimited) however, these required the use of a fixative in a bleaching bath that would eliminate and replace the by the dye.

F. 28: Toning. Examples of toneds by sulphur, coper and green-blue Agfa.

2.151.4 - Stability

In all of the systems used for the introduction of colour in prints, the stability of the colour depends, of course, on the stability of the dye used. For this reason, in a single film, we can find sections that may retain their original colours in perfect condition, together with sections in which the colour has evidently faded or darkened.

In any case, the determining of whether the colour appearing in an old film is the original or whether it is a product of degradation is a practically impossible task. It would be necessary to have a precise knowledge of the original formulas –those used in each film-- and this is not possible, not even in the case of the films pre-tinted in their manufacturing process.

F. 29: Deterioration of a tinting.
In the last shots of this print, the green pre-tinting has turned into a strange color sepia/amber.

In some of the colours most often used, such as the shade generically referred to as "Prussian blue", the degradation may result in the total fading of the colour, the fading of the colour in some areas of the film or, on the contrary, the blackening of the colour.

Another characteristic commonly found in tinting and toning systems was that the various coloured sections had to be joined together in the prints.

F. 30: Prints cutting
Cutting on the print of a tinted section and a toned section.

The tinting and toning systems were used jointly or alternatively in many films. Depending on the intensity sought for the colouring effect, the film could be only toned or only dyed, could be toned and dyed after processing, or pre-tinted supports could be used with the toning being performed after processing.

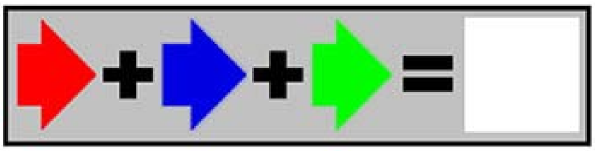
F. 31. Film tinted in yellow and toned in azul. The humidity has affected the tratment of the colour, fading and removing the dye used in the toning.
(Immage obtained from a reproduction on colour emulsion)

Following the introduction of sound, some manufacturers continued to offer tinted stock for prints, in softer tones, compatible with the needs for transparency in the sound reading systems, however, the requirements for sound editing rendered its use unfeasible.

2.152 – Reproduction of Natural Colour

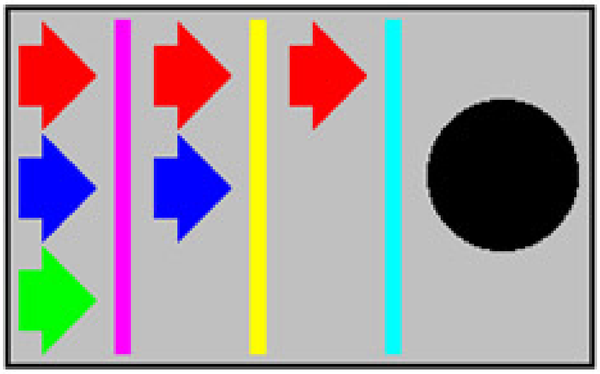
Once the chromatic sensitivity of the photographic emulsions made it possible to reproduce the brightness values corresponding to all of the colours of the spectrum (panchromatic emulsions)[55], it was possible to consider the photographic reproduction of natural colours.

There are two possible systems for the reproduction of colour:



- Additive synthesis, in which the sum of the lights of the primary colours red, green and blue reproduces white light.

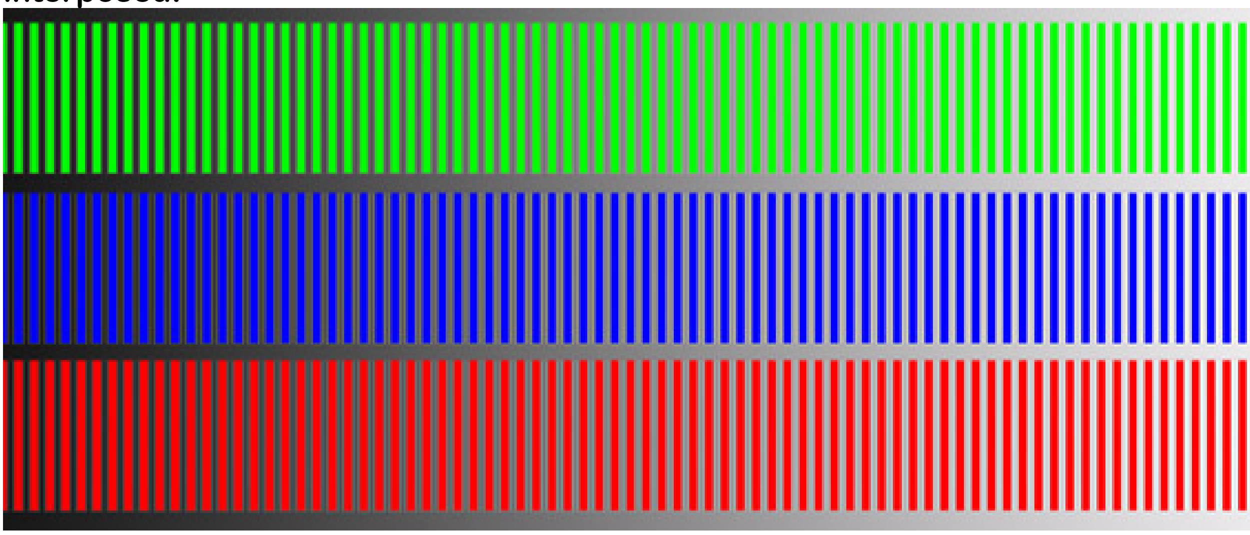
55 As was demonstrated later, some additive synthesis attempts made with emulsions sensitive only to blue (such as the one made by Maxwell in 1861), only achieved results apparently; the filters prepared on the plates that were supposed to pick up the green and the red were imperfect and allowed part of the blue and the ultraviolet to pass through, and the lights were what formed the black and white image on those plates.



- Subtractive synthesis, which used the complementary colours, magenta, cyan and yellow (also called "secondary" or "primary subtractive" colours) which when cumulatively subtracted by means of filters completely block the passage of light.

In additive synthesis, similar to that performed by visual perception, the brightness and shading of the colour are perceived simultaneously and independently, with the visual mechanism itself being what relates and unites the two parameters.

In subtractive synthesis, the bright areas corresponding to the intensity of the light for each colour reach the eye modified by the shading of the filters interposed.



F. 34: Additive analysis
In this bar-scheme, the saturation of the colour bands is identical but it seems to vary as it varies (of black to white) the shine transmitted from the plane of bottom of the scheme.

2.152.1 – Additive Synthesis Systems

All of the initial attempts to cinematographically film the colours of the exterior reality were made on this kind of system.

Starting with emulsions that record the images by means of the blackening produced on silver crystals, the motion picture systems based on additive synthesis had to meet two conditions:

- Divide the images into their red, green and blue components; selecting the brightness values corresponding to each colour and recording these brightness values separately in black and white.
- Present in projection the image corresponding to each of the primary colours completely separate from that of the others and covered by the relevant colour.

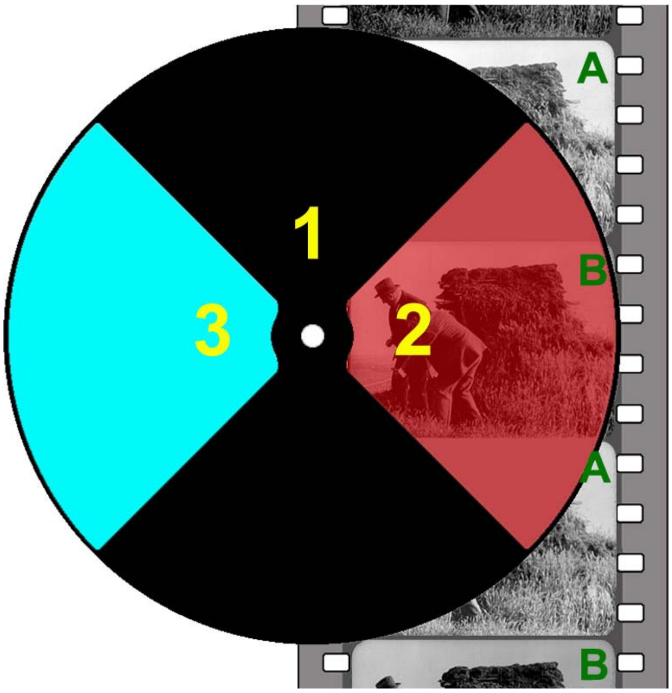
In practice, a simplification was introduced into many systems, being restricted to the obtaining of separations for the red and the blue-green (cyan) or for the

orange or the red-orange and the cyan. These bichromes produced a not very bright but acceptable sensation of "natural colour".
The systems presented can be grouped into four categories:[56]

- Systems based on the successive addition of monochromes.
- Systems based on the simultaneous addition of monochromes.
- Optical reseau systems.
- Chromatic reseau systems.

None of these systems met with true industrial success, and the additive synthesis of colour has only achieved industrially efficient solutions in the electronic image systems.

2.152.11 – Systems Based on the Successive Addition of Monochromes[57]



In these systems, the separate colour frames were filmed successively in a camera that moved the film two or three times the normal speed.

Both in filming as well as in projection, a shutter with two or three windows with filters of the selected colours was introduced which rotated synchronizing each filter to the exposure/projection of a frame.

F. 35: Monochromes' succesive addition
Diagram of projection of a "Kinemacolor" type system.
[1] Shutter. [2-3] Red/orange and blue/green filters. [A] Frame selected for the blue/green. [B] Frame selected for the red/orange.

During the filming, these filters selected the light corresponding to each colour; in projection, they restored the colour corresponding to each image to the black and white.

When projected at 48 or 36 images/second, the visual perception could make the synthesis of the colour correctly, however, even though the filming had been made at those same speeds, the successive images of the figures in motion did not fully coincide, which gave rise to "slipping" between frames, which should have been / registered, and "smeared" the images.

In the United Kingdom, several of these systems were developed. The systems used by Smith were trichromes; the Kinemacolor, commercialised by Charles Urban, operated only in orange and green-blue bichrome.

2.152.12 – Systems Based on the Simultaneous Addition of Monochromes

Basically, these systems were the same as the previous ones, but dispensed with the rotating shutter, replacing it by a system of three or two lenses,

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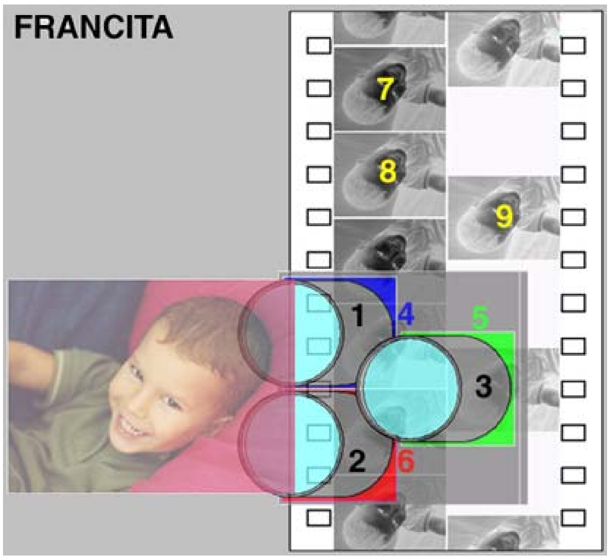
56 Some of the terms in Spanish used in the drafting of this section come from: *Fernández Encinas, José Luis: "Técnica del cine en colour"*. Industrial Engineers School, Madrid, 1949

57 This system of filming, which in some environments is known as "sequential filming", is also used in some of the subtractive synthesis procedures; but restricted to the filming of the negative and reproducing the two frames on only one in the positive print.

equipped with filters that were to be used both for filming as well as for projection.

The Gaumont Chronochrome used a tower of three lenses that filmed simultaneously on three successive frames. In the projection, the three frames were projected superimposed, using the same filters as for shooting.



In the Francita system, a three-lens tower was also used, however, these were arranged circularly in such a way that they produced three small frames on a 35mm. film.

F. 36: Monochromes' simultaneous addition.
Diagram of filming in the Francita system.
[1-2-3] Lenses.
[4-5-6] Selective filters for blue, green and red.
[7-8-9] Images for color separation corresponding to the blue, red and green lights, on a 35mm panchromatic film.

Other systems used two lenses, placing the two images in a parallel arrangement on the 35mm. film.

The impossibility of achieving an exact superimposition of the images during projection prevented the success of these systems.

The preservation of the prints or the negatives, in black and white, of the motion pictures filmed according to systems based on the addition of monochromes involves no difficulties other than those of any other film in black and white.

However, their reproduction in colour, both in projection as well as by printing on modern colour emulsions, presents significant and complex problems, which depend, among other reasons, on the compatibility of the filters originally used with the possibilities of the subtractive emulsions.

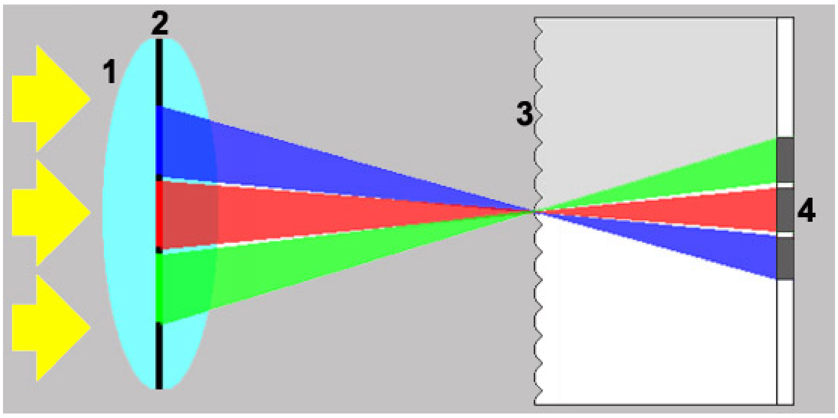
2.152.13 – Optical Reseau Systems

The reseau (optical or chromatic) systems were the only additive synthesis systems that managed to acquire a degree of industrial significance.

The optical reseau systems were initiated with the experiments of Berthon and Keller-Dorian. Multiple attempts were made on the basis of these experiments (using prismatic or spherical reseau) however, only the systems developed by Kodak and Agfa managed to obtain commercial results.

These systems used films in which the support side had been moulded in order to produce an uninterrupted succession of cylindrical lenticular elements, arranged crosswise to the film.

The emulsion was placed on the underside and the images were filmed through the reseau of cylindrical lenses which, depending on the manufacturer, had different gauges (46µ in the Kodakolor and 28µ in the Agfacolor).



F. 37: Optical Reseau Systems
[1] Lens.
[2] Slit with three filter bands and two opaque bands of separation.
[3] Base-face, modelled forming a traverse lenticular cylindrical reseau.
[4] Image of three strips white and black.

The images reached the film through a filter made up by three strips of colour, red, green and blue, separated by two narrower opaque strips.

The image was formed on the central strip of each cylinder of the reseau and was conveyed to the emulsion forming an image of strips with the intensities of brightness corresponding to each of the colours. The opaque strips of the filter brought about separation strips between the colours that protected each strip of colour from the influence of the adjacent colours.

The system was repeated in projection, placing the filter on the outside of the lens.

The Kodacolor film appeared in catalogues in 1928 and the Agfacolor additive in 1932. Both were marketed in 16mm, for reversal processing, however, satisfactory systems for printing were never developed for them.

The Kodacolor and Agfacolor additive films are materials in black and white. Their reproduction on modern colour materials, rebuilding the system of lens and triple filter, can present tremendous difficulties on account of the irregularities subsequently introduced in the dimensions of the supports.

2.152.14 – Chromatic Reseau Systems

Dufaycolor was the only chromatic reseau procedure that was used in cinematography and was also the only additive synthesis procedure to achieve industrial success.

The reseau was made up by strips of gelatine filters 25µ wide.

The strips of the red filter were continuous and were arranged in the lengthwise direction of the film.

The green and blue strips were placed crosswise in segments located between the continuous red strips.

The reseau was made to adhere to the support by means of six extremely complex and successive operations and was coated with a black and white emulsion, protected in turn with an opaque varnish to be eliminated during processing.

F. 38: Chromatic reseau
Frame of an animated pictures film shot in Dufaycolor and detail of the reseau.

The photography was performed through the support, with the light passing through the reseau and impressing the areas of emulsion located under the colours contained in the lights with the relevant value of brightness.

The opaque or grey areas in negative, following reversal developing or a positive printing, allow the light to pass through the filters thus rebuilding the colour on the screen.

The Dufay system, created for still photography, was presented on reversal motion picture film around 1930. Its development as a negative and positive system was begun around 1936, and a number of commercial motion pictures were made using the systems in different countries.

The difficulties for achieving the precise superimposition ("on register") of the filter strips during printing and the low level of light in this kind of film undermined its ability to compete with the subtractive systems.

The Dufaycolor films are the only additive films that carry the colour filters on the support itself[58] and the preservation of the colours in the gelatine filters is liable to be extremely irregular, including within the same film.

Apart from the problems that can arise from the irregular degradation of the colour filters, the exact reproduction of the Dufaycolor originals is practically impossible with present-day subtractive emulsions, as they are unable to simultaneously repeat the shades of the three primary colours of the filters.

2.152.2 – Subtractive Syntheses Systems [59]

The subtractive synthesis of colour is based on the possibility of obtaining all of the colours by intercalating filters of the complementary colours, magenta, cyan and yellow, in a beam of white light. [60]

When the filters of the primary colours, typical of the additive systems, are used by inserting only two filters in the beam of white light (red + blue, red + green or blue + green) the passage of light is cut off completely, while in subtractive synthesis, the light subtracted by two filters continues to allow the radiation of one of the primary colours to pass through. Thus:

- A magenta (purple) filter will transmit blue and red radiations; a cyan (blue-green) filter will allow green and blue light to pass, and green and red lights will pass through a yellow filter.

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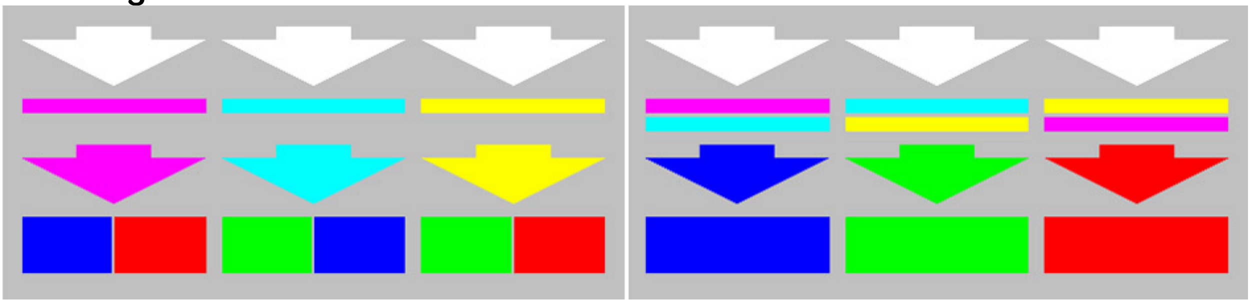
58 Except for some examples of prints, prepared for the system based on the successive addition of monochromes, absolutely handcrafted and in which tinting by hand was used in order to colour the film frame by frame and alternatively, with the colours of the filters.

59 This system was described a 1869 and almost simultaneously by Charles Cros and Louis Ducos du Hauron.

60 Occasionally, the complementary colours are called "subtractive primary" colours and also, although incorrectly, "secondary colours ".

- If two filters are combined: blue light will still pass through magenta + cyan (or cyan + magenta); yellow + cyan (or cyan + yellow) will allow green light through, and the yellow + magenta (or magenta + yellow) filters will transmit red light.



As was the case with additive systems, in many subtractive systems the problem was simplified by electing to produce bichromatic images by using magenta or orange and cyan.

Possibly tens of systems existed at one time, however, the majority did not manage to go beyond the experimental stage and their use in a few short films.

These systems have multiple variations that include differences ranging from the characteristics of the emulsions to the number of negatives, to their arrangement in the camera, to the arrangement of the emulsion (or emulsions) on the prints and to the procedures used for their reproduction or for the production of the colour.

At present, it is not possible to establish a classification that could completely encompass and define each of the systems.

By weighing the commercial significance attained by the systems and in view of the proportions between negatives and positives and the colour characteristics of the emulsions, a classification into two groups can be proposed:
- Production of the colour in the prints.
- Three-layer films for colour.

2.152.21 – Production of the Colour in the Prints[61]

In the systems of this group, both the negatives and the prints were made on black and white emulsions and the colour was introduced directly on the prints, relating the amount of colour received by each point of the frame with the image densities that had been obtained in black and white.

Technicolor, which is by far the most important of these systems and the only one with lasting industrial success, presented basic differences and should be considered in a separate subgroup.

2.152.211 - Systems with Two Negatives and Toned or Coloured Prints

Systems of this type were developed in many countries and were used from 1915 until 1954[62].

- Both for shooting as well as for reproduction, black and white film was used.
- The negatives were filmed by filtering the light for blue and orange or for blue-green (cyan) and red-orange.

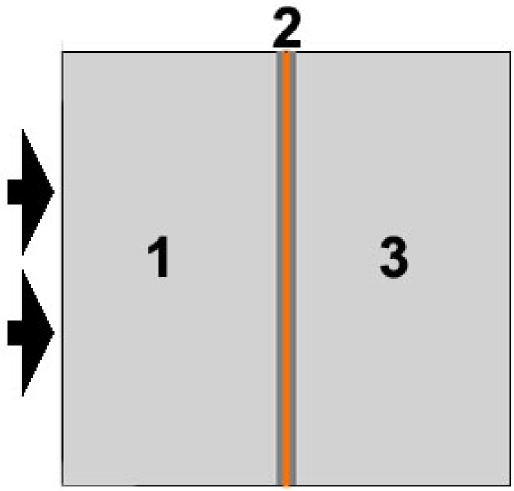
61 Some concepts used in this section are based on: The Gamma Group: "Film Archives On Line".

62 The Cinefotocolor system, developed in Barcelona (Spain), which was possibly one of the later systems devised, was used to make 14 feature films between 1948 and 1954.

- One of the negatives was orthochromatic and sensitive to green and blue lights; the second was panchromatic and recorded the values of light corresponding to the orange-red colours.

There were three procedures for filming:

- The filming was done at twice normal speed, using a shutter with two gates fitted with primary colour filters and filming one frame under each one of the filters, one after another.
- Dual cameras were used, which were capable of moving two rolls of films synchronised and independently and were equipped with a prism for splitting the beam of light and of filters for the selection of colour.
- The two negative films were arranged on a single roll, superimposed in what was called a film bipack; in this method (which might have been the one used most widely) a standard camera was used.



F. 40: Bipack Agfa
[1] Film with orthochromatic emulsion filmed through the base.
[2] Orange filter.
[3] Film with panchromatic emulsion.

Different film manufacturers (Eastman, Agfa, Gevaert, DuPont) included films rolled in bipacks in their catalogues for use in filming under these systems. In the bipack negatives, the two films, orthochromatic and panchromatic, were placed in emulsion contact, and the image was exposed through the support. The films of the bipack were only handled together during filming and were separated for developing and, of course, for reproduction. The bipacks of each manufacturer were different in the arrangement of the emulsions and in the inclusion of filters. In the Agfa bipack, the image was exposed through the orthochromatic film. On that same film, covering the emulsion, there was an orange filter (that was eliminated during the developing process) that protected the panchromatic emulsion located on the second negative from the blue and green lights.

The prints were also made on black and white emulsions. In some cases, standard print stock was used, while in others, the standard stock was re-emulsified (on the same side or on the support side) after the processing of the first negative and, finally, in other systems, films coated with an emulsion on both sides were used (Kodak 's "Duplitized", DuPont's "Duplicoat", Agfa's "Dipofilm", etc).

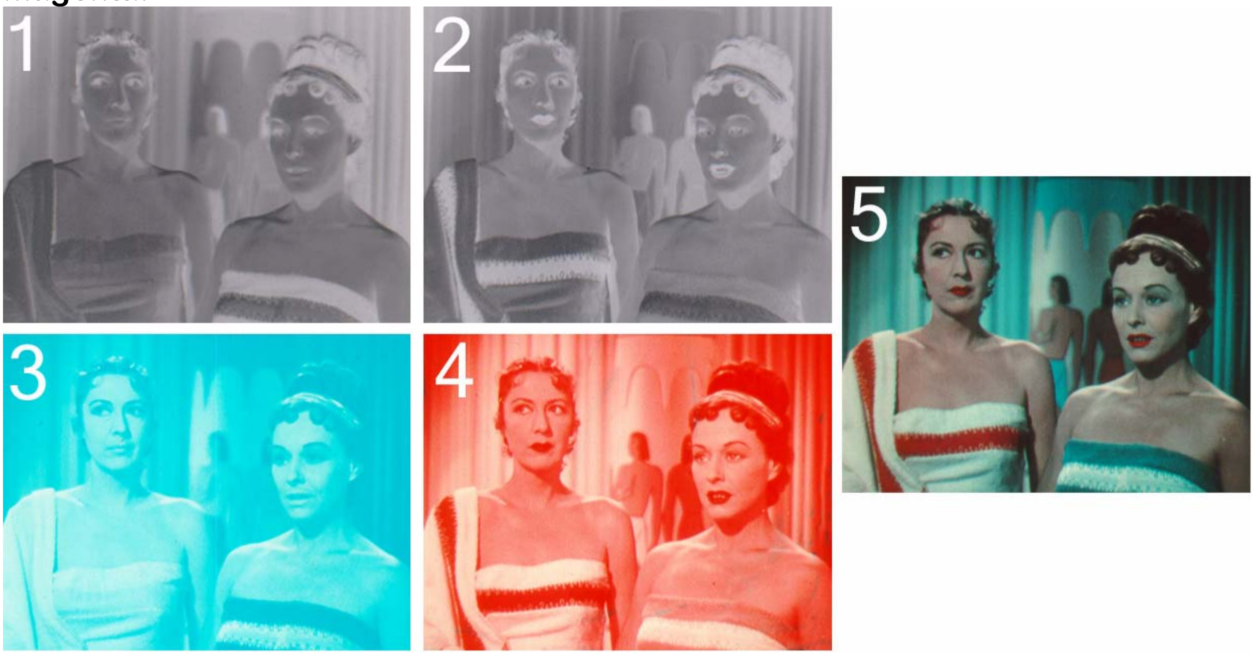
Although in the reproduction of the copies, there were as many variations as there were systems, some common aspects can be noted for the majority of the systems.

- The two negatives were copied separately.

- The image obtained from the panchromatic negative (corresponding to the red-orange lights) was toned in a blue-green colour.
- The image obtained from the orthochromatic negative (corresponding to the blue-green lights) was toned in magenta.
- The lack or the low intensity of the yellow was offset by means of the use of slightly tinted supports or the direct tinting of the film.

The toning could be performed by using a single system, for example, by direct substitution with Prussian blue and orange prepared with uranium ferricynanide; or two systems could be used, for example, Prussian blue and an organic red-orange dye applied to the mordant.

The Dascolour system, which used standard black and white film, first processed the film with the negative corresponding to the red-orange, which was toned to blue-green (using Prussian blue) and then, after sensitising the film once again, printed and processed the blue-green image, which was toned to magenta.



F. 41: Substractive two-colour process.
Cinefotocolor system (on an example prepared by M. Daniel Aragonés). [1] Orthochromatic negative for the cyan image. [2] Panchromatric negative for the magenta image. [3] Image toned to cyan. [4] Image toned to magenta. [5] Final image.

The Cinefotocolor system (in its second version) followed the same order of reproduction, but the first reproduction was made through the support and by inserting a filter (to limit the penetration of the light), so that no more than the lower half of the emulsion was exposed; after developing and toning, the second negative was reproduced on the upper half of the emulsion (now with the emulsions properly facing each other) and a second development was effected together with a fresh toning, and then the fixing process was applied.

The number of variations was so great, including within each system (for example: Trucolor and Cinefotocolor used standard stock and stock with emulsions on both sides) that there is little point in attempting to describe all of the systems and their variations.

The cataloguers who inspect films in these systems must study the material held by them carefully, together with the available bibliography, in order to be able to identify them. In the preservation of the films made on the basis of these systems, the problems of negatives and positives can be radically different.

The negatives are negatives in black and white.

Normally, if they were properly processed, the emulsion will keep well, however, even though this may be the case and the chemical degradation of the support has not progressed as far as the deterioration of the film, it will be very difficult or impossible to obtain a fresh reproduction from them, given that the contraction of the support will prevent the positioning of the two negatives, successively and with absolute precision, in order to reproduce each frame without creating double images.

Moreover, if well-preserved prints obtained in the original are not available, all of the descriptions as may be found concerning the dyes used (including in the patents of the systems) would only serve to orient the work: the exact shades of the colours used in the original reproduction of each film cannot be determined by means of written references. [63]

With respect to the prints, the central problem resides in the preservation of the dyes. All dyes fade (although some more than others) and they do so unevenly.

By means of destructive chemical analyses, it is possible to determine precisely the dye used, however, many more elements come into play in the action of the dye, including the gelatines, the water, the residues from the developing process, the temperature and speed of the dyeing, the photographic density, and the like, and any one of these elements could have influenced the specific degradation of a colour in a print or, of course, could have introduced alterations into the colour qualities of a specific print which has managed to survive.

On approaching the study of the colour in a film made in any of the additive or subtractive systems mentioned above, or in Technicolor or, even in some aspects, on examining films made under modern systems, we must keep in mind that:

- The systems of separations in black and white, of filters or of dyes and tonings, were of a highly experimental nature, and their creators and promoters subjected them to constant changes and improvements.
- At least during the forties, the fundamental reason for creating and using these systems was to economise. All of these systems were much more economical (or industrially more accessible for each cinematography) than Technicolor and, thus, many of their components were essentially inexpensive and replaceable.
- By means of these systems, it was not possible to reproduce the authentic "natural" colours completely, which allowed the persons responsible for each film and for the laboratory ample scope of action in order to make changes in the colour, almost, in every single print. [64]

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63 In any case (and this is true for all of the systems for the reproduction of colour and for the study of colour restoration), the criteria for the reproducibility of the colour in the prints have varied over time and have been much more flexible than at present. In silent films, it was practically routine for each distributor to obtain prints with the shades he wished, and for the reproduction of many films, only generic instructions were prepared, such as, for example, "this scene in orange". In the additive or subtractive colour systems and even in Technicolor itself for prints, the colours of the filters or of the dyes varied almost in every single print. Induding with the modern three-layer films, a change in brand or type of film can introduce significant variations in the shades reproduced on the copies.

64 J. Aragonés, creator of the Cinefotocolor system, on discussing his procedures for obtaining prints, noted that, after its reproduction, each print roll was analysed in order to determine the intensity of the yellow dye that needed to be added to it..

2.152.212 - Technicolor

On account of its technical characteristics and its importance for the diffusion of colour films, Technicolor is a system that should be considered separately from any other. In Technicolor, the introduction of the colour is achieved by means of a printing procedure, through the transfer of the images, colour by colour, through imbibition onto one single copy support, the photographic characteristics of which were used for reproducing the sound.

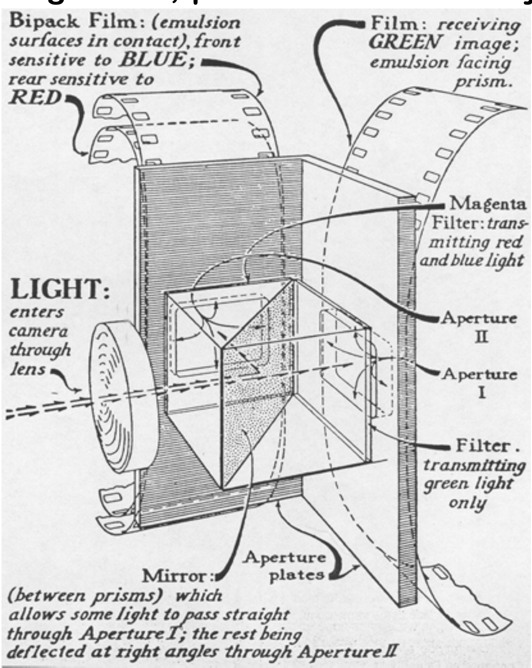
The Technicolor system has been used as a complete system –from filming to the striking of prints- but also as a system for obtaining prints of films made with three-layer negatives.

At the start of the twenties, Technicolor was a system with two negatives and colouring of the prints by toning; its sole unique characteristic resided in using a very rustic procedure for obtaining prints (the complete reproduction of each colour on a different film and, then, cementing, support on support, the two films). A few films starting in 1922 were made in this kind of Technicolor. In 1928, Technicolor initiated the development of its system of printing by imbibition, first in bichromes and, as from 1932, in trichrome.

Starting in 1935 and up to the definitive establishment of the negative→positive films for colour (during the fifties) Technicolor became the basic system for motion pictures in colour.

The facilities derived from using a standard camera in shooting led to the use of the Technicolor system for the reproduction of prints in films made with three-layer emulsions. For many years, Technicolor was very competitive for obtaining the distribution prints, and its use endured up to the seventies (in China until the 90's). When filming for the Technicolor process, cameras were used with a single lens, placed in front of a system of semi-reflecting prisms and equipped with two motors that pulled three reels of film in a synchronised manner (two of which were rolled in a bipack).

The light that passed through the semi-reflecting mirror reached a green filter and made an exposure on negative no. 1. The light deviated by the mirror was projected onto a purple/magenta filter that allowed the blue and red radiations to pass through to the bipack; there, the first film (negative no. 2) received the light through the support and was equipped with a Blue-sensitive emulsion, in such a way that it only picked up the light corresponding to blue; a red filter/layer (which would be removed during processing) was coated on the emulsion of this film to shield the panchromatic emulsion of negative no. 3 from the blue light.



F. 42: Technicolor filming system
Ilustration taken from the journal "American Cinematographer", VIII – 1981, pg.792.

At the end of the production stage, and once the negatives were edited, the printing matrixes were reproduced in positive, and these were then used for making the transfer to the projection prints.

The positive material of the matrix was exposed through the support, thus reversing its geometry (to give it the complementary geometry of a negative) and exposing the parts of the emulsion closest to the support. A hardening bath would then harden the exposed areas of the emulsion, which, after being developed and fixed, were subjected to a special rinse that eliminated the gelatine from the surface areas that did not contain a photographic image, thus obtaining a surface in relief, the higher parts of which corresponded to the greater photographic densities of the positive image.

F. 43: Technicolor positive separation duplicates
Target frames of:
[1] Image selected for the blue.
[2] Image selected for the green.
[3] Image selected for the red.

In order to transfer the colour, the matrixes were loaded with dye: the one originating from negative no. 1 (selected for green) with magenta dye; the one from negative no. 2 (blue) with yellow and the one from no. 3 (red) with cyan dye. The embossing was made successively and placing each of the matrixes in contact with the "blank" gelatine of the film for the print. Finally the gelatine layer was hardened. The matrixes absorbed and transferred the dye in relation to their thickness, achieving an exact correspondence with the photographic densities.

Following the arrival of the three-layer films, the Technicolor process was adapted in order to obtain the matrixes from Kodachrome originals or from Eastman Colour negatives.

As in the two-negative procedures, the preservation of the Technicolor negatives and prints poses different problems. With respect to the negatives, if they were correctly processed and the chemical degradation of the support is not a determining factor, the irregular contraction of the three supports will make it very difficult to superimpose their images exactly in order to reproduce

them. In the positives the problems will arise from the possible degradation of the colorants.[65]

2.152.22 – Three-Layer Films for Colour [66]

Attending to the needs of the industry, the handling of the equipment and systems necessary for reproducing the colour in any of the foregoing procedures was a constant source of problems. And not only because, for example, the Technicolor cameras were double the size of the standard cameras or because the Dufay prints had to be processed necessarily in Dufay laboratories, but rather because the obtaining of the desired colours was, print by print, an excessively complex adventure.

What the industry wanted were solid systems that could be handled by procedures similar to those of black and white and with which reasonably consistent results and qualities of colour could be obtained in each reproduction. The development of the three-layer films for colour would end up converting the desired simplification into a reality. [67]

A colour film is a set of three superimposed emulsions prepared for recording, separately and selectively, the light corresponding to the blue, green and red radiations of the spectrum, and for reacting during the processing in order to produce the yellow, magenta and cyan dyes.

In order to produce a film of this type it was necessary to have emulsions sensitive to all of the colours of the spectrum – which was achieved by means of the development of the orthochromatic and panchromatic emulsions – and of the substances appropriate for forming the colour in the emulsion of the films; this second part of the problem did not have a satisfactory solution until the mid thirties.

In 1909, Rudolf Fischer discovered that the dyes could be formed together with the images during development of the film[68]. In order to achieve this, it was necessary to use substances that would be capable of reacting together with the silver. Also, the solubility of these substances in the water of the baths would need to be such that it could be controlled with absolute precision. .

The availability of substances[69] capable of forming the colour during development was relatively immediate. Fischer himself found dyes that could be incorporated into the emulsion and react jointly with the silver in a developer of phenylenediamine mixed with a naphthol or phenol. In 1911, Fischer proposed to situate the agents forming the three subtractive colours, separately, in three different and superimposed layers in a single film.

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65 M. Gómez, in a statistical study made at Filmoteca Española, did not detect signs of modification of the colour in the Technicolor prints kept in this archive; nevertheless, although the colour in each print was homogeneous, between different prints of the same film there were significant differences in colour. (see: Mariano Gomez: "La degradación del color. Estudio estadístico y ensayo de tipificación". In: *"Textos del VI Seminario/Taller de Archivos Fílmicos". Electronic edition, Filmoteca Española, Madrid, 2001*).

67 En la descripción de las características de estas emulsiones se han seguido los criterios expuestos por el Dr. Hubertus Pietrzok en el texto anteriormente citado.

67 At different times, the three-layer films for colour were defined as integral tri-pack films or monopack films for colour.

68 This type of developing, which act s simultaneously on the halides sensitised by the light and on the dyes, is known as chromogen or chromogenic developing.

69 The terminology employed for these substances is extremely confusing. They are called *color formers, color couplers, color radicals, chromogeneous radicals, chromogeneous couplers, color matrixes, color precursors or color components.*

In order for the dyes to be effective, it was necessary for them to be spread throughout the thickness of the layer, however, controlling the diffusion of these substances through the extremely thin layers of the emulsion was a very complicated problem.

All of the possible colour couplers known by Fischer and his followers were soluble in water, and the permeability characteristic of the gelatines (permeability that makes photographic processing possible, on allowing the baths to penetrate deeply) prevented the control of the solubility of the dyes incorporated into each layer: the dyes of each layer spread to neighbouring layers and even leaked out of the emulsion into the developing baths.

Around 1935, Agfa and Kodak launched their Agfacolor and Kodachrome films, which solved the matter of the control of the diffusion of the dyes from two completely different perspectives: Agfa, following Fischer's original scheme, incorporated the coupling chromogen into the emulsion; the Eastman film was made up by three layers for black and white, and the colour formers were introduced into the developing solutions.

The difference between the two solutions was fundamental. Although both were presented for reversal processing, the Agfacolor procedure could be developed prior to 1939 in films for negative→positive system, while the original Kodachrome procedure could only be used as reversal.

2.152.221 – Three-Layer Films for Substantive Processing

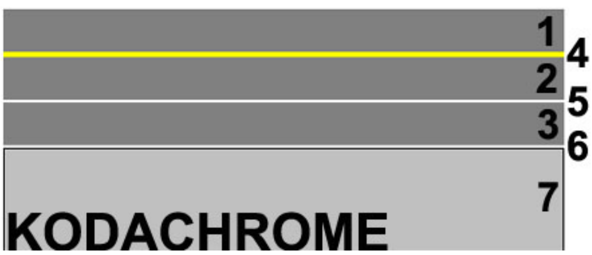
The Kodachrome by Eastman was created directly for cinematography and was introduced to the market as 16mm, reversal film for non-professional use, to be returned to the manufacturer for developing.

In the still photography terrain, the Kodachrome film was highly successful, as Kodak introduced the "idea" of placing the "slide" images obtained in the camera in 50/50mm cardboard frames.

The Kodachrome was also used in professional cinematography as camera film for subsequently obtaining the Technicolor matrixes, thus avoiding the clumsy dual cameras for this procedure.

Basically, Kodachrome is a developing procedure.

The film has three layers for black and white (sensitive to blue, green and red) with a yellow layer/filter situated under the layer sensitive to the blue and another layer of gelatine, inserted between the green and red layers, in order to favour the control of the diffusion of the dyes. The colour formers are dissolved in the developing solutions and are added to the film during processing.



F. 45: Kodachrome
[1] [2] [3] Layers sensitives to blue, green and red. [4] Yellow filter.
[5] Emulsion coating.
[6] Adherent substratum.
[7] Base.

This kind of processing, which contributes the colour formers, is known as substantive processing. [70]

70 References are often found to the Kodachrome films as "non-substantive films" (the "substantives" being here the films that carried the colour precursors), and "non-substantive processings" are also

Kodachrome processing was performed by two procedures and, in both, the first phase is a normal black and white development. In the first procedure, extremely complex and which reached the point of consisting of more than 30 phases, the processing was performed by means of successive development and bleaching processes. In the simplified system, the film received three selective re-exposures (to red, blue and white lights) and three chromatic developing processes that produce cyan (interior layer), yellow (exterior layer) and magenta (intermediate layer); the processing ends by eliminating all of the silver.

The preservation of the colour in the Kodachrome films seems to be satisfactory.

In the study made by M. Gómez, at the Filmoteca Española, despite originating from unsatisfactory storage facilities and evidencing heavy deterioration due to wear and tear, none of the Kodachrome samples analysed revealed fading or alteration of the colour. [71]

2.152.222 – Three-Layer Films with Couplers Incorporated

In order to control the diffusion of the colour formers incorporated into the film during processing, two different procedures have been used.

The technology used by Agfa consists of enhancing the affinity between the dye and the gelatine, by increasing the size of the dye molecules by means of the introduction of carbon chains in the molecule.

The first Agfacolor subtractive film was introduced at the start of 1935 as a reversal film, and the Berlin Olympics were filmed with it in 1936. Following the German defeat in the Second World War, this technique was copied by other manufacturers.

The Kodak technology, developed in the forties, was based on introducing the dye molecules in the emulsion, after rendering them non-soluble in the water of the baths. For this purpose, the dyes were treated with a fatty high-boiling-point solvent, shaped into tiny “spheres” of resin or gelatine; the dye "spheres" were mixed with the gelatine of the emulsion and were closely associated with the crystals of the halide.

The technique developed by Agfa distributed the molecules evenly in the layer of gelatine. In the Kodak technology, the "spheres" did not have an even distribution but rather solved this problem by means of their "association" with the photosensitive crystals.

Around the middle of the fifties, Perutz developed a mixed technique in which he used enlarged molecules (similar to Agfa) for the magenta and yellow couplers, and fatty molecules for the cyan.

2.152.223 – Reversal three-layer films with included couplers

Up to the decade of the fifties, the difficulties in order to obtain a good balance of colour in the copies led to the use of the three-layer films with the coupler included basically in reversal systems, which limited their use by professional filmmakers.

Initially, the reversal films were designed for non-professional uses in the field of home cinema and for still photography.

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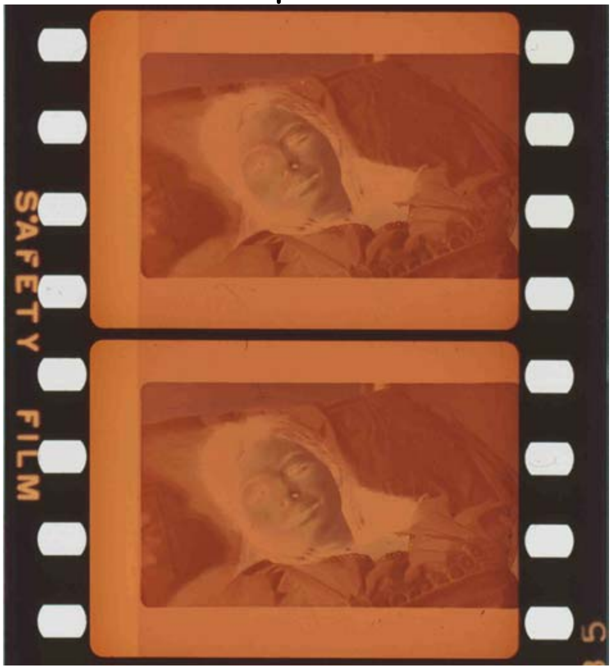
mentioned in order to refer to procedures that did not provide the colour formers.

71 Mariano Gómez, work refered.

In the professional terrain – and apart from the use of the Kodachrome as a camera film for Technicolor – the reversal procedures would take on major importance for films made for scientific, educational and military purposes and in the field of television news casts, in which they made it possible to save a significant amount of time, although they made it necessary to edit directly on the camera film and to synchronise the sound on separate magnetic supports.

Manufacturers have developed multiple kinds of reversal film, for daylight and artificial lighting, with different speeds and chromatic sensitivities and have even provided for duplication systems (with or without integral masking) in order to obtain reproductions from reversal camera films.



A reversal film for duplication that attained a certain degree of importance was the Eastman Colour Reversal Intermediate 5249/ 7249. It was a reversal film with an integral mask and was used to produce colour negatives, duplicated from other negatives, in a single reproduction operation.

F. 46
Eastman Color Reversal Intermedite

2.152.224 – Three-Layer Films for Colour with Integral Masking

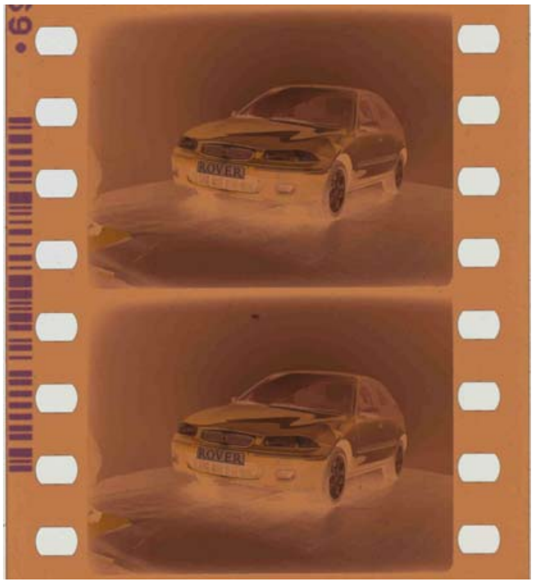
The definitive expansion of the emulsions for colour in cinematography had to wait until the solution of a problem that was preventing the obtaining of duplications and reproductions without losing the quality of the colour.

The layers of a colour film must be selectively sensitive to the light corresponding to blue, green and red, and carry the colour formers, yellow, magenta and cyan.

Thus, after developing, the yellow layer should absorb all of the blue radiation and transmit the green and the red; the magenta layer should completely block the green and transmit the blue and the red, and the cyan dye should absorb the red radiation and allow the blue and the green to pass through; however, in practice, dyes that absorb and transmit the colour radiations adequately have only been achieved for yellow. The magenta and cyan dyes produce unwanted absorptions by modifying the light they transmit and, consequently, the colour. The magenta dye absorbs some blue light and introduces yellow, and the cyan dye retains some of the blue and green light that it should transmit.

The impurities of colour produced by the unwanted absorptions are small, however, obtaining a good reproduction in colour is much more difficult than to do so in black and white.

In B&W, a 10% variation in the amount of light transmitted by the print could practically go unnoticed; in colour, a much smaller variation in the amount of light transmitted by a layer completely upsets the balance of colour and could produce unpleasant and surprising effects.



In the system developed for solving this problem, the chromogen couplers were introduced into the film were coloured with an insoluble dye. This dye, pink in the cyan and yellow in the magenta, coincided with the shade produced by unwanted absorptions. In the completely transparent areas of each layer, the insoluble dye had a homogeneous colour density, and this density varied inversely to that of the image until disappearing completely in the areas of maximum density.

The inversely proportional variation of densities between the insoluble dye residue and the image is that which gives rise to the term of integral masking; this is the term that describes how the dye residue forms a mask that covers the film in the exact proportion in which the film is not covered by the density of the image.

The colour produced by the unwanted absorptions causes irregular deviations in the balancing of the colour in each frame. Naturally, on account of its uneven nature, there is no means whatsoever for correcting these deviations in the colour and, in each successive reproduction, the importance of these deviations will increase.

If in a camera original, the deviations can be admitted, in the prints they will be perceptible and, in the event of using the commercial system of duplication (original negative ÷ positive duplicate ÷ negative duplicate ÷ release prints) the significance reached by the deviations of the colour will render the final reproductions totally unacceptable.

Starting in 1950, Kodak initiated the introduction of the series of Eastmancolor films. The products for negatives and prints in successive years were followed by emulsions for negative duplication and by the so-called "intermediate" emulsion, suitable for positive or negative duplication.

F. 48: Eastman Color Intermediate positive duplicate with integral mask.

In these emulsions, the integral masking presents the image as if it had been filmed on an orange film and, in effect, a layer of orange, apparently homogeneous, fills in all areas maintaining some degree of transparency in the film. The orange, on account of its homogeneity, can be corrected in the reproduction by means of the use of appropriate filters. Naturally, on account of the aforesaid orange colour, the integral masking cannot be used in emulsions (print or reversal) that are to serve the purpose of viewing the filmed images.

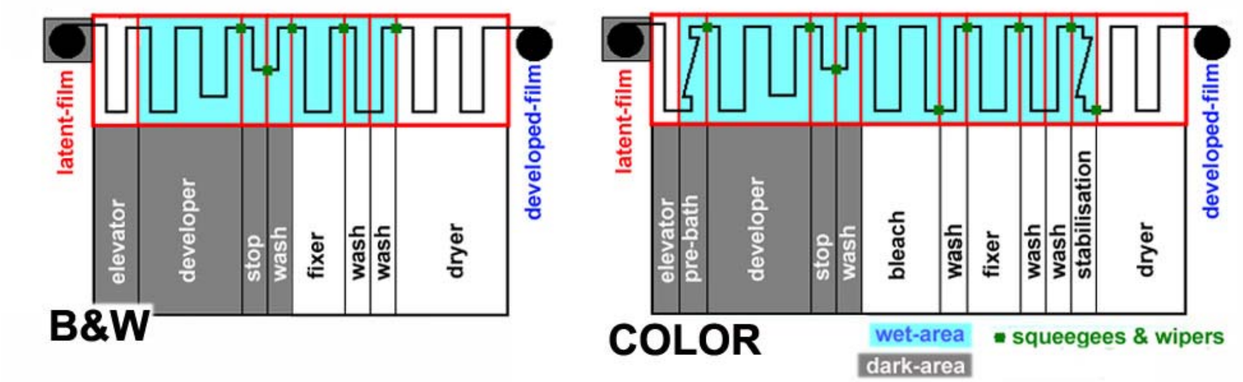
Little by little, Agfa-Gevaert, Fuji, Orwo, Ferrania and other manufacturers went on to offer their own variations of this system, which also extended to reversal emulsions for duplication. But the predominance obtained by Kodak, thanks to the need of using its Eastman Color Intermediate emulsion for the obtainment of positive duplicate[72], was clearly reflected in the gradual acceptance by all of the manufacturers of the procedures proposed by Kodak for colour processing; procedures that were to be accepted and implemented in the cinematographic laboratories and that can normally not be changed on account of the needs of a particular (and not dominant) brand of films.

Just as the industry wanted, the processing of colour films followed procedures similar to those for black and white.

During development, the bath acts on the latent image, in each layer of the film, producing silver images and, as a second part of the same process, the oxidised developing agent (created on producing the silver image) reacts with the chromogen coupler bonded to the image in each layer of the film, creating insoluble dyes of the secondary colours. In this way, during the development phase, two images are produced in each layer, one in silver (black and white) and the other in colour, the densities of which are exactly proportional.

The following phase of the processing is a bleaching (similar to that performed in the reversal processing) by means of which the metallic silver image is destroyed, transforming it once again into the original silver bromide to enable its elimination.

On entering into the fixing phase, all of the silver existing in the film, which was affected by the light in the exposure and which formed the image, will be in the form of silver bromide and, the same as occurs in the black and white processing, the fixative bath will dissolve all of the silver bromide existing on the film, leaving it ready for removal when washed. The only stable element that will remain of the images formed during development will be the three colour images.



The last phase of the process, the rinsing of the film, is essential for preserving the image. The silver bromide and all of the residues of the products used during the processing must be removed from the film in order to prevent them from affecting the dyes. The rinse bath also must also contain a solution with colour stabilising agents for the film.

72 In 1986, Fuji offered its Fujicolor intermediate film F-CI. 8213 onto the market.

The destruction of the silver image during the bleaching bath made it necessary to introduce an intermediate phase for the processing of the sound tracks in the prints made on colour films.

By means of a normal colour processing, the image of the sound track would be comprised solely of the colour layers and would not have the optimum density required for the reproduction of sound.

In order to preserve the silver image of the sound track, after passing the film through the bleaching phase and prior to immersing it in the fixing bath, the sound area passes over an “applicator wheel” that coats it with a layer of viscous developer for black and white. The developer once again transforms the silver bromide into metallic silver, which, thus, will not be eliminated by the fixing agent. As a result, the image of the sound track is made up by two images: one in colour and the other in silver.

In the last few years, the introduction of sound readers appropriate for working solely with the colour image is being proposed. These readers would eliminate the need for keeping the silver image.

There are other three-layer subtractive systems for motion picture films, such as Gasparcolor, which was used in cartoons, or Pantachrom, also German, created by Agfa.

The Gasparcolor system used a three-layer film, in which each layer was sensitised for one of the primary colours and dyed with its complementary colour. After each layer of colour was exposed and developed, the colour filter was eliminated in the areas where the silver image had not been formed, and, following this process, the bleaching and elimination of the silver image was performed. In this way, the image of each layer was made up solely by the dye, which had been associated with the silver image.

The existence of the three layers of dye on the film meant that the Gasparcolor materials had an extremely low sensitivity and could only be used for obtaining prints from three originals in black and white of the kind used in Technicolor.

The stability of the colour in this film, similar to that of Technicolor, has led to a proposal being made for using it (or to use a similar system produced for photography, Cibachrome) in making preservation prints for archives.

2.152.225- Layer Structure

In the three-layer films, two arrangements have been used in the organisation of the layer structure.

The first, usually called the "characteristic arrangement", follows the range of spectral sensitivity of the emulsions. It is used in all of the negative and duplication films, as well as in the reversals and in print stock for systems such as the Agfacolor in the thirties and forties or, later, in Orwocolor or Sovcolor.

The "characteristic arrangement" is as follows.

1. Exterior layer, sensitive to blue (blue sensitive), in which the yellow will be formed.
2. Filter-layer dyed in yellow to protect layers 3 and 4 from the radiations of the blue zone of the spectrum.
3. Intermediate layer, sensitive to green (orthochromatic), in which the magenta will be formed.

4. Interior layer, sensitive to red (panchromatic), in which the cyan will be formed.

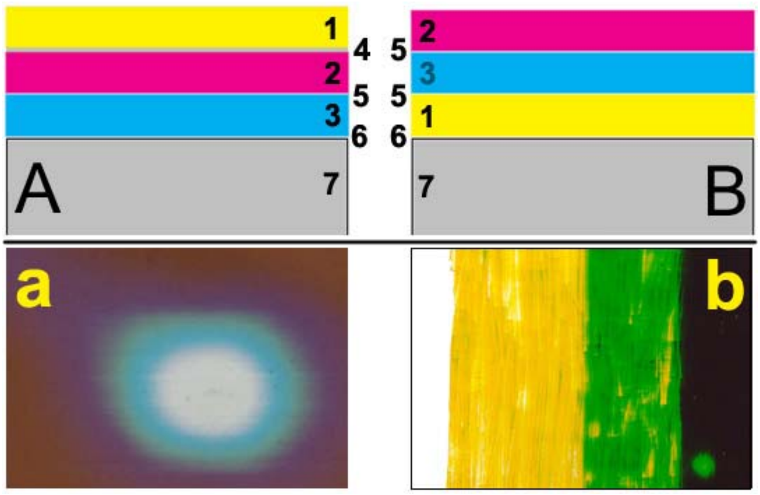
The second arrangement is normally known as “exchanged layers”. It was introduced by Kodak and is used in print stock.

1. Exterior layer, sensitive to green, containing the formers for the magenta.
2. Intermediate layer, sensitive to red, in which the cyan will be formed.
3. Interior layer, sensitive to blue, in which the yellow will be formed.

In this print stock, the "red" and "green" layers have their sensitivities adjusted in such a way that their reaction to the blue light is much less than to the red or green lights and, as a result, require very lengthy exposures.

An arrangement of layers and sensitivities of this kind can only be used in films that are going to be exposed in a printer, in which, because the exposure can be adjusted, the low speed of the film is not very important.

F. 50: Layers arrangement
[A]- Characteristic arrangement. [B]- Arrangement of interchanged layers.



[1] Layer sensitive to blue that contains the color couples of yellow. [2] Layer sensitive to green that contains the colour couples of magenta. [3] Layer sensitive to red that contains the couplers of cyan. [4] Yellow filter. [5] Layers of gelatine to control the diffusion of the dyes. [6] Adherent substratum. [7] Base. [a] Detail of a negative with integral mask in which the emulsion has been scraped off to showthe layers structure. [b] Detail of a print in which the emulsion has been scraped off to show the layers structure.
(Images by Mariano Gómez)

2.152.3 – Fading of the Colour in the Three-Layer Films [73]

All of the dyes that can possibly be used in photography alter over time.

In reality, all of the dyes –of any kind and for whatever use—change with the passage of time, and it is impossible to conceive of a system that will guarantee their preservation indefinitely.

The dyes used during the silent period for tinting and toning, as well as those used for two-colour subtractive processes or in Technicolor, are reasonably stable although, over the course of time, all of them fade, lose saturation or darken, but it is in the chromogen couplers that are used in the three-layer emulsions where the problem of the fading of the colour has reached its greatest intensity and, together with the acetic degradation, the fading of the colour constitutes the thorniest problem confronting our present-day film archives.

In order to approach this problem we are going to make use of the proposal made by H. Pietrzok in his earlier referenced contribution to "Preservation and Restoration of Moving Images and Sound". This author considers the causes of the degradation by classifying them into two groups: those derived from the

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73 Some of the criteria put forward by the Grupo Gamma in the works referenced earlier have been considered for writing this section..

characteristics of the film itself and from the procedures through which it is processed and handled, and those that are brought about by external factors, for example, the storage conditions.

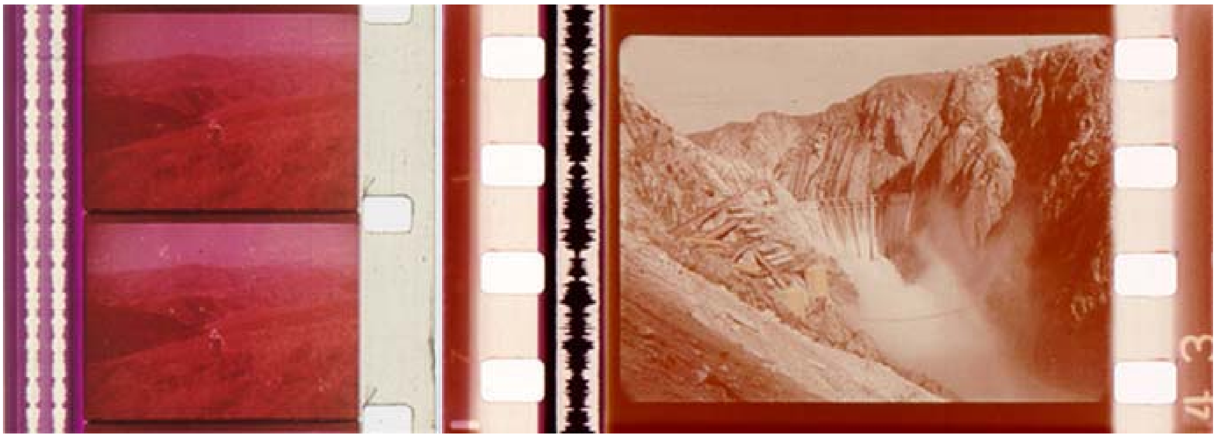
2.152.31 – Endogenous Degradation

The stability of the dyes themselves is, without a doubt, an important factor, and the dyes used for the colour couplers are three or four times less stable than the azoic dyes used in Technicolor or Cibachrome. [74]

In all of the subtractive colour systems, the magenta layer has apparently been the most stable and, in the day-to-day practice in archives, the characteristic magenta colour that the degraded prints acquire is daily evidence of the superior stability of this dye.

Nevertheless, the magenta layer is very sensitive to the action of the residues of the agent used in the fixing of the silver image (thiosulphate); if the stabilisation rinse does not eliminate these residues adequately, the magenta fades, and the film acquires a marked greenish tone.

The destructive action of the residual thiosulphate is faster when fatty couplers are used as colour formers. This action also reaches the yellow and cyan dyes, but to a lesser degree and in a more homogenous manner.



In general, the stability of the cyan dyes produced with fatty colour couplers is superior to that of those produced with water-soluble couplers.

Up to the end of the seventies, with the introduction of Kodak's LF (Low Fading) films for prints, the cyan had been the most unstable of those contained in the three-layer films; the improvements achieved for this dye have relegated to the yellow the highly dubious honour of being the dye with the least stability.

The intrinsic instability of the dyes, mainly that of the cyan and the yellow, is an undeniable factor in the fading of the colour, however, this factor does not appear to be the decisive one. In all archives, there are prints in which the colour has not degraded, and those prints are on materials of the same brand and age as others that are completely decayed.

F. 52: Print obtained in 1969 on material Ferraniacolor and preserved in conditions identical to others prints that present important fading of colour.

74 H. Pietrzok, article mentioned earlier.

In addition, the dyes used in the manufacture of the negative and duplication emulsions are substantially the same as those used for the prints, and as all of the archives can verify, the negatives with degraded colour are only abundant among those filmed prior to the mid fifties; in subsequent negatives, including those filmed in the sixties, the degradation of the colour is not very frequent; on the contrary, the degradation of the colour is a frequent occurrence on prints of any kind which are only a few years old.

F. 053: Fading of colour in negatives. Frame of a print obtained from a negative highly deteriorated (Gevacolor, processed in 1954)

The influence of the chemical degradation of the supports in the deterioration of the colour is another factor to be considered.

The decomposition of the celluloid, including in early stages, before the chemical degradation becomes visibly evident in the material, produces nitrogen dioxide, a gas that deteriorate the dyes rapidly; a 0.1% content of this gas in the atmosphere of the inside of a container of film brings about a significant reduction of colour density in just 24 hours, mainly affecting the cyan image. Fortunately, due to chronological circumstances, the films produced on cellulose nitrate supports and three-layer emulsions are relatively few.

Available studies demonstrate the existence of a relationship between the acetic degradation of the cellulose acetates and the fading of the colour: the increase in the acidity of the emulsion (the inevitable result of the production of acetic acid by the degradation of the support) seriously jeopardises the cyan dye.

However, not even this appears to be a determining factor. Although in all of the films evidencing the existence of a serious process of acetic degradation, a deterioration of the colour is observed, some films show the early signs of acetic degradation (a slight vinegar odour) and appear to keep their colour perfectly well and, of course, the fading of the colour also comes about on triacetate supports that are not affected by acetic degradation.

The polyester supports do not appear to release gases that could damage the dyes.

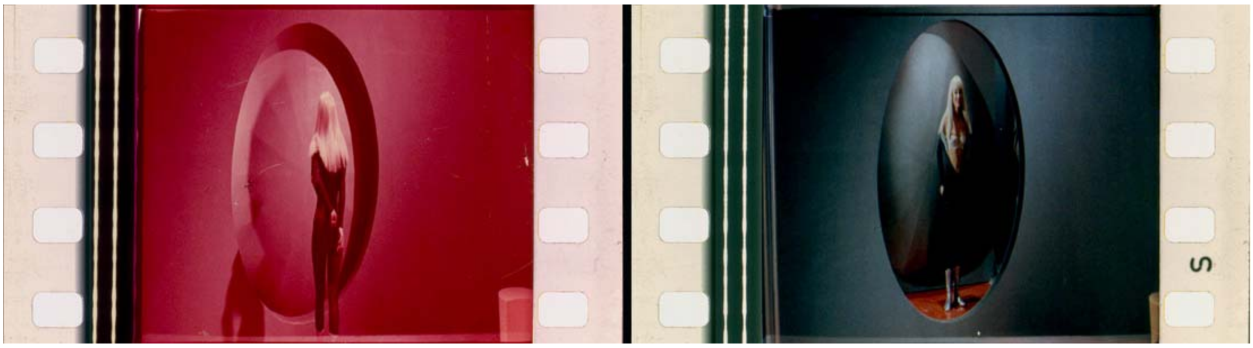
The conditions in which the films are processed constitute the third important factor for the deterioration of the colour. The experience of archives indicates that this may be the fundamental factor. However, it is unfortunately also the least controllable of all.

The standard Kodak systems for processing colour took many years in achieving a generalised acceptance and, even so, the concept of standard processing is very relative, using chemicals from different suppliers for the preparation of the baths. The standard systems have varied in fundamental

specifications (such as temperatures and speeds) on many occasions, which, obviously, must involve differences in the action of the baths, and above all, in the effectiveness of the final rinse. Finally, each laboratory can modify (and does modify) the constituents and procedures used in processing, according to its experience and needs.

This accumulation of variables, totally uncontrollable by archives, may perhaps be the explanation for the differences that are observed in the preservation of theoretically equal films from the same era.

Also, it is evident that the widely different results obtained in the preservation of the colour in negatives and duplication materials and in the projection prints, can be related to the differences existing between the products used in the processing of both kinds of material and (perhaps and fundamentally) to the processing speeds and temperatures.



F. 54: As an evidence, the different situation of these two images – obtained from the same negative duplicate, one in the seventies and the other at the end of the nineties – the duplicate preserves its color values intacts.

The stabilisation rinse with which the processing concludes is a fundamental phase for the preservation of the colour. The components of the baths of the process are difficult to remove from the layers of gelatine. The sodium thiosulphate of the fixer is difficult to eliminate and even in very small amounts affects the preservation of the colour image. The thiosulphate also affects the silver image in the black and white film, but is much more aggressive with respect to the colour image.

Despite its importance, the final rinse should be performed within certain limits that will not alter the balance of the pH in the emulsion. Dr. Pietrzok notes that if the film maintains an optimum pH, the deterioration of the colour image will occur at a slower speed. The optimum pH is different for each kind of film, ranging from between pH 5-6 for the Eastmancolor 5385 and pH 7-8 for the Orwocolor PC 7; similarly, each dye maintains a different relationship with the variations in the pH of the film.

On a number of occasions, preservation washing (re-washing) has been proposed for the materials kept in archives.

Systems have been designed in order to detect the excessive presence of residues from the processing baths in the emulsion. The systems are relatively complex, and it would be impossible to use them for negatives (in which, tests would have to be performed for at least each scene). However, they can be used, roll-by-roll, for projection prints and duplicates. The preservation re-washing bath should contain the same stabilising solution as was used in the original processing.

2.152.32 - Degradation by the Action of External Agents [75]

Light, air, temperature and humidity are the environmental agents that can act on the film.

In the conditions in which the motion picture films are handled and kept, light is not a problem of concern. The ultraviolet radiation of sunlight and of the projection lamps is harmful to the film, however, the films are normally kept in opaque containers, and their exposure to the light in the projector window is very brief[76]. It is true that, during processes of review, the films are exposed to light for a much longer time, however, these processes are normally performed in moderate lighting conditions.

F. 55: Frames exposed to light. The color cyan, first, and then the magenta quickly disppeared under the action of the light, while the yellow resisted few weeks of exposition. The soundtrack's silver image virtually doesn't present deterioration (Samples prepared by Mariano Gómez in the Filmoteca Española).

The action of light affects the three layers, although possibly in an uneven manner. In a small-scale study made in the Filmoteca Española, films exposed to different intensities of light (including direct sunlight), acquired a yellowish-brown colouring that evidenced significant losses of colour in the cyan and magenta levels. The fading of the magenta can be extremely fast if the exposure to the light coincides with very high levels of humidity; in such condition and even in a matter of hours, the magenta disappears completely, leaving a green film behind.

F. 56
The combined action of sunlight and extreme humidity of an icy morning of spring, provoked the almost total fading of the magenta layer of this work print in only 24 hours.

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75 In the drafting of this section, the criteria set out by Herbert Volkmann in "The preservation of dyes in developed colour films". *In: "Preservation and restoration of moving images and sound" - Chapter 5. FIAF, Brussels, 1986,* have been taken into consideration.

76 For each frame of a projection print shown three times per day for a period of seven days, the total exposure in front of the window would not amount to five-tenths of a second. Nevertheless, it should be noted that, in the Filmoteca Española, colour prints have been observed to carry a mark (like a "shadow") that could only be attributed to the projection window.

The action of the gases on the emulsion should be considered from two different points of view.

The environment of cities and industrial areas can hold significant amounts of sulphur and other products that are harmful to the emulsions. Whenever possible, archives should be established in areas with a low atmospheric pollution level or, alternatively, appropriate systems of filters should be installed in order to prevent these pollutants (which are large-size molecules) from entering the storage areas.

The importance of ventilation for the preservation of films has already been dealt with under the headings concerned with the degradation of the plastic supports and microbiological contamination. For the preservation of the dyes, ventilation is also a basic factor.

The concentration of gases of nitrogen dioxide or acetic acid inside the containers or the storage areas is directly harmful for the colours. The separation of the films with an inflammable celluloid support should be made simply for reasons of safety, but also because the gases produced by the decomposition of the cellulose nitrate accelerate the degradation of the colour in the safety films that may be exposed.

High temperatures and humidity deteriorate the colour quickly and seriously. This same comment was already made on discussing the acetic degradation, for the preservation of the colour; the problem is even more serious.

In order to preserve the colour, temperatures as low as -18° centigrade have been proposed, and the Preservation Commission of the FIAF, in 1986, proposed -5° and 25% RH. These temperature and humidity ranges may possibly appropriate for preservation, however, they involve extremely complex problems (which have not fully clarified) which will be discussed in the section devoted to the fitting-out of preservation storage areas.

Nevertheless, in everyday practice, the importance the extremely low temperatures may have for the preservation of the films has not been totally explained. In the storage areas of many archives and laboratories, the temperature is around 18° centigrade and, in such condition, once again, what can be observed is that degradation of the colour comes about in the prints, and not (or, at least not perceptibly) in the negatives.

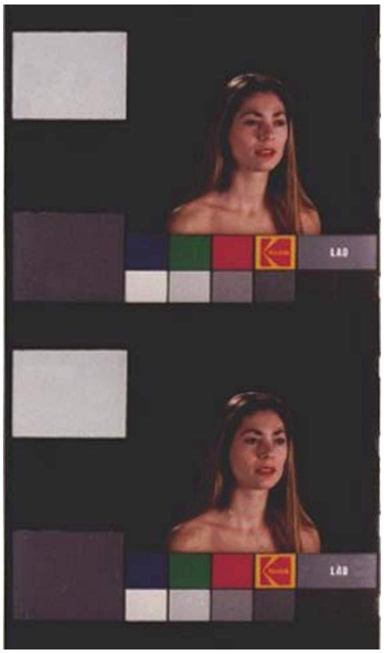
The high levels of humidity (over 50% RH) do appear to have a direct impact on the degradation of the colour in all kinds of film.

From a general standpoint, the preservation of colour films is a completely different matter if, in order to undertake such preservation, the negatives and prints from the premier reproduction (or obtained in the same laboratory, with the same grading and on the same print stock) are available and in good condition, in comparison to only having recourse to the negatives.

In a similar manner to what was discussed for the other colour systems -- additive and subtractive—the information on the colour is not completely contained in the negative. The reproduction lights, the characteristics of the baths and of the print stock itself can modify the colour finally reproduced.

The keeping of the laboratory information on grading and processing and the details of the materials selected for the release print stock can be fundamental in order to ensure the preservation of the film.

Description of the LAD image.
The modern standard negative is Kodak's LAD negative - the Laboratory Aim Density negative, used for analyser set up and for duplication set up. The large white and black patches are used to evaluate the full tonal range. The white patch in the LAD Control Film scene is 90% reflectance and the black patch has 2.5% reflectance, which approximates to the range of reflectance found in most scenes. The unlit black plush area behind the girl's head provides a true shadow reference. There is sufficient flesh area for densitometry and evaluation of the flesh tone. The three colour patches (blue, green, red) are included to add a little colour to the scene and to help identify any colour separation exposures that might be made. The small grey scale at the bottom of the scene is used for subjective evaluation of grading and reproduction and can be used to objectively set the gamma controls on an electronic colour analyser.
(From: The Gamma Group "Film Archives On Line")



F. 57: The LAD strips, incorporated to the negatives and reproduced in the prints can give a very reliable information about the characteristics of duplication and the processing of each material.

2.2 - Magnetic Film and Tape [77]

When dealing with describing magnetic recordings, it is interesting to note that one of the characteristics most highly valued with regard to these systems, is something of great concern for an archive, the possibility of these recordings being erased and their supports reused78.

2.21 - Magnetic Recording Support Development

Magnetic recording systems are based on the possibility of using an electromagnetic field to unify the pole-related direction in which a stock's molecules are arranged.

77 Although it be an arbitrary differentiation, the term "magnetic film" is usually employed with regard to the perforated film used in filmmaking technology, the term "tape" being employed with regard to unperforated stock.

78 In Spain and many other countries, during the Forties, the lack of cinematographic supports increased the removal of emulsion from the prints (and even the negatives) of movies ending their release in order to use the bases, emulsioning them again, for the manufacture of negative sound material and print. Presently, in the television industry, above all in the small local television channels, the tapes are used over and over again, provoking the loss of an enormous quantity of registers with high informative value.

All the molecules, of any type, have magnetic properties, but, in their natural state, their minute molecular magnets are pointing in all different directions, thus counteracting the stock's magnetic properties. When this stock is placed under the effects of a sufficiently strong magnetic field, the polarity of their molecules is then pointed in the same directions as those of the field, the stock hence taking on magnetic properties. But solely ferromagnetic stock, such as iron, nickel, cobalt or chromium (as well as different alloys which may include non-ferromagnetic stock) will tend to keep their molecular magnets pointing in this direction, to remain polarised and to continue to be true magnets once the induction field has ceased exerting its effects.

In 1888, Oberlin Smith described the basic principles on which magnetic sound recording might function, ten years following which Valdemar Poulsen would patent his "Telegraphone", a magnetic sound recording device employing steel wire moving at a speed of 200 centimetres/second, achieving recordings of up to 50 seconds in length. In 1901, Mix & Genet (Berlin), presented a similar system which ran on a steel band measuring 3 millimetres in width and 0.5 millimetres in thickness, this band being wound on reels and, although running at the same speed, producing much longer recordings. Around 1934, the Marconi Wireless (London) recorders employed reels of steel tape moving at a speed of 150 cm/s, producing recordings as long as 30 minutes in length. The attempts to introduce these tapes into the filmmaking industry failed, though the Marconi recorders met with great success at the BBC during World War II. In the late 1920's, Fritz Pfleumer (Germany) began developing systems employing paper or plastic strips coated on one side with a magnetic emulsion. And, in 1935, A.E.G. presented the first recorder that ran on magnetised plastic tapes as per the Pfleumer procedure, these tapes, manufactured by I.G. Farben, moving at a speed of one meter/second.

The surface of the paper strips was too rough, which, hindering continuous contact with the reading head, created a greater deal of background noise, in addition this paper support not being flexible enough or retaining its shape well enough to withstand the pressure on the heads, this strip therefore curling and losing many of its acoustic qualities.

I.G. Farben also manufactured single-layer tape on which oxide particles were mixed with the PVC in the support, but the magnetic densities were quite low in this single-layer system, the tapes therefore being only minimally sensitive.

Two-layer tape (plastic support + magnetic emulsion) proved itself to be better than any other. Wires and steel bands were heavier and thicker, allowing for shorter recording times, remaining magnetised to a lesser degree and causing a considerable "echo" effect. Single-layer plastic tape was less sensitive and led to greater wear of the reading heads, and paper supports did not last nearly as well, in addition to their signal/noise ratio being much lower. Besides, the two-layer plastic tapes allowed the editing of recordings by means of a system as simple as cutting and splicing.

Following World War II, magnetic-coated plastic tapes became the number one solution over all.

Magnetic tape production was promoted by companies that were already manufacturing similar products, such as the 3M Company and the manufacturers of filmmaking industry stock.

In principle, they were manufactured on plain, unperforated diacetate or triacetate supports, measuring 25/1000 mm and 38/1000 mm in thickness. The perforated 35mm and 16mm supports for the filmmaking industry were manufactured in triacetate up until the 1970's, in exactly the same thickness as those used for videotape.

In the 1950's, BASF introduced PVC supports, providing for greater mechanical strength and stability and excellent emulsion adhesion. This plastic would make it possible to manufacture films in thicknesses of slightly over 10/1000. PVC supports have been used for audio and videotapes, but have hardly been used at all for perforated film.

Smooth polyester (Mylar) film, which was first used in the 1960's, provided the best stability and a smoother surface (hence, with the highest signal/noise ratio). Mylar film stopped being used because this type of film could stretch out of shape, leading to signal impairment. This problem was completely eliminated as a result of a double (biaxial) stretching being added to the lamination process.

Polyester's great mechanical properties have enabled the manufacture of tapes measuring up to 8/1000 in thickness. For perforated magnetic supports, films of 40/1000-50/1000 in thickness are used. Polyester supports have ousted all of the other types of tapes off the market.

Magnetic tracks adhered to the filming support proper have been widely used in classic filmmaking. These magnetic tracks are placed on the film (before or after filming and developing the picture) using a roller applicator system, removing the photographic emulsion from the area where applied if they are placed on that side of the support. These tracks are used on 8mm, 16mm, 35mm and 70mm films.

F. 58: Magnetic tracks adhered
35mm combined print prepared with two magnetic tracks adhered for the film dubbing. 16mm with a track for sound register and another narrow track to balance the rolling.

2.22 - Tape Lengths & Recording Times

Regarding magnetic audio and video tapes, thickness is a major factor for determining tape-handling ease. Tape speed is gauged in centimetres/second, and the thicker the tape, the larger in diameter will have to be the reel to hold the tape. Therefore, thinner tapes being developed have made it possible to make longer recordings using reels of the same diameter.

Emulsions have also become progressively thinner as new magnetic particle media have been developed, though in this field thicknesses have not decreased across the board, and the thicker oxide emulsions continue to be preferred for some professional audio jobs.

The recording speed is limited by the tape's magnetic density, a determining factor as regards its sensitivity, and by the requirements of the systems for recording high frequencies.

For those systems, which record sound longitudinally, many different speeds, ranging from 300 cm/second to 2.38 cm/second have been employed. Three speeds have been standardised for: 15", 7.5" and 3 3/4" per second, unencased-tape analogue recordings [79]. Depending upon their thickness, audiotapes are classified into standard-length or long-length (double, triple, etc.) reels or cassettes.[80]

For perforated films used in the filmmaking industry, the speeds are exactly the same as those used for the picture for each film gauge.

For digital audio systems and for all video systems, the amount of information to be recorded on each centimetre of tape has made it necessary to resort to new strategies to reduce the speed at which the tape moves.

Whilst, for an analogue audio system, the information to be recorded entails an 8KHz-20KHz bandwidth, a 1MHz-2MHz bandwidth for digital audio systems and up to a 5 MHz bandwidth for video systems is required. These large amounts of information would obviously require tremendous speeds (of up to 3,800 cm/s for video recording purposes) or alternative strategies for distributing the signal on the tape.

The two-inch video tapes (AMPEX and RCA) implemented a cross-sectional recording standard resulting in the tape speed being slowed down to 15 i/s (38.1 cm/s). All of the systems thereafter, known as spiral recording systems, have run at even slower speeds.[81]

Compressed formats have also been implemented in digital systems, having made it possible to even further reduce the amount of tape used.

Two systems have been used for digital audio. The formats that employ fixed heads, recording longitudinally, distribute the signal simultaneously over several parallel tracks. The tape running speed depends on the sampling characteristics and the format. Therefore, the running speeds for the DASH format are 30"/s-7"/s; for the PRODIGI format, 15"/s-7"/s; and 4.76"/s-2.38"/s for the S-DAAT format. Other systems have gone the same route as video and employ rotary heads running crosswise, multiplying the recording length. These systems include the U-matic, which takes tapes in this video format directly, while the R-DAT format takes tapes 3.81mm in width by 13µm in total thickness, which makes it possible to record up to two hours of sound on 60 meters of tape.

79 For audiovisual systems, many basic concepts are stated in feet and inches. One foot equals 304.8mm and, in 35mm, one foot of film equals 16 frames. This division is not actually exact and, in keeping with the basic length standard (the perforation gauge), 16 frames of print film total 304mm. The speeds given in inches (one inch = 2.54mm) are equivalent to 38.1cm/s, 19.05 cm/s and 9.52 cm/s.

80 See Textual Note VIII in the end notes.

81 The following table has been prepared based on the data provided by Gordon White in "Video Techniques" (I.O.RTVE, Madrid, 1989 - 2nd edition).

VIDEOTAPE RUNNING SPEED (analog systems)								
Format	Quadruplex	1'B	1'C	U-matic	Betacam	Betamax	VHS	V-8
Speed	38.1 cm/s	24.3 cm/s	23.98 cm/s	9.53 cm/s	10.15 cm/s	18.7 mm/s	23.39 mm/s	20'05 mm/s

Additionally, due to the characteristics of digital recording, it has been possible to make tapes and emulsions noticeably thinner, resulting in a considerable gain in the diameter/length ratio.[82]

2.23 - Magnetic Coating Characteristics

The main characteristic of the coatings employed in manufacturing magnetic tapes is that of their inconceivably wide-ranging variety, this being a variety characterising both the composition of the plastic resins of the binder and the magnetic metals and oxides, and the thicknesses of the sensitive layer and the arrangement of the particles. Apart from this, the processes entailed in the processing, application and finishing of the magnetic pastes involved many critical points (that cannot be controlled from the archives) which may entail variations in tape characteristics and durability.

Amidst all this confusion, those archives which are able to select the stock they use to preserve their magnetic recordings can solely abide by the good old rule of selecting a well-known, tried-and-true brand and continuing to use that one same brand.

2.231 - Types of Magnetic Particles and Layers Used

Three different compositions have been used for the sensitive layers for manufacturing magnetic tapes:

- Layers comprised of oxide particles + binder resins.
- Layers comprised of metal particles + binder resins.
- Layers formed by metals vaporised onto the support.

The large majority of the tapes used, including all of the perforated films for filmmaking purposes, fall into the first of these three categories.

Metal and vaporised metal tapes first started being used in the 1970's, and it was only as of 1990 that they would gain a foothold among significant audio and video tape market segments. These tapes require specially-prepared equipment to be used and are the only ones suitable for use for some audio and video formats.

2.231.1 - Oxide Tapes

Gamma ferric oxide (γ Fe_2O_3) has been and continues to be the oxide used most in tape manufacture.

Gamma ferric oxide is a synthetic product of great magnetic stability which is processed from natural ferric oxides precipitated into an alkaline medium and reduced in a rotary furnace at temperatures below 400ºC. To improve their magnetic stability, certain amounts of chromium can be added to the original ferric oxides.

The particles of this oxide form needle-shaped particles measuring less than one micron in length which are five to ten times smaller in diameter. For tapes of this type, the coercivity threshold is relatively narrow, falling within the 200-350 oested range. For professional video, these tapes were used in cross-recording recorders.

Chromium dioxide (CrO_2) particles are of magnetic properties similar to the gamma oxide particles, but are much more regular in shape and can be added to

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82 Ken C. Pohlmann, en "Principles of Digital Audio" (McGraw-Hill, Inc., New York, 3rd Edition, 1995. P. 176) states: "Base thickness for professional analog tape is about 35µm, and the oxide thickness is about 15µm. [...] With digital tape, base thickness is about 20µm and oxide thickness of 5µm".

the emulsion in much higher concentrations. For this type of tapes, the coercivity threshold falls within the 300-700 Oe range.

Chromium oxide tapes are highly abrasive and must be used in systems equipped with ferrite heads. These tapes are more highly heat-sensitive, which may deteriorate the magnetic properties of the chromium dioxide.

Gamma oxide tapes have also been manufactured combined with cobalt. Cobalt can be added to the oxides during their preparation (contaminated oxides) or may be spread over the surface of the needle-shaped particles once formed (oxides with absorbed cobalt). By using these systems and controlling the proportions of cobalt, tapes with quite broad margins of coercivity have been developed to encompass from 150 Oe up to 800 Oe and above. Some of these tapes are extremely sensitive to high temperatures, their magnetic properties possibly being diminished in warm environments.

2.231.2 - Metallic Tapes

The use of metal particles increases remarkably its magnetising possibilities, it being possible to achieve coercivities within the 1000 Oe - 1200 Oe range.

Different metals or alloys may be used in these tapes, one of the most common alloys being an iron particle, cobalt and nickel alloy.

The dimensions of the resulting needle-shaped particles are up to ten times smaller than those of the oxides (approx. 0.04 µm), which makes it possible to achieve very high levels as regards recording density and signal/noise ratio and optimum time length characteristics for the recorded signals.

For evaporated metal tapes, the metal particles are affixed directly to the support without using any binder resins. Either ferromagnetic alloys (such as iron, chromium, cobalt or nickel) or non-ferromagnetic stock (such as wolfram) can be used in these tapes, and the particles will be in the shape of granular crystal clusters.

This type of sensitive layers are very delicate both due to their being extremely thin (on the order of 0.15 µm), which makes them highly sensitive to losses due to abrasion on the reader heads, and to requiring corrosion-proofing treatments in order to withstand high humidity.

Due to their abrasive characteristics and to the recording densities metal tapes can provide, they can only be used in equipment specially designed for this purpose.

2.232 - Magnetic Tapes: Main Characteristics & Processing

Magnetic tape components are selected to retain the recorded signal and to provide the finest sensitivity and fidelity-related features, as well as to allow for each tape to be used as many times as possible.

2.232.1 - Residual Magnetism, Coercivity/Sensitivity and Signal/Noise Ratio

A stock's ability to retain the magnetic alignment of its molecular magnets is termed "residual magnetism", which is the prime property required of stock for use in the manufacture of sensitive layers for magnetic recording purposes.

The residual magnetism of an emulsion depends, first of all, upon the particle type, shape and degree of clustering and is closely related to another emulsion property, coercivity, which is indicative of the degree to which the particles withstand losing their magnetic flow.

This resistance must fall within some very narrow margins, which are marked by the need to prevent accidental demagnetisation and to allow the recording and erasing of the tape.

The greater a particle's ability to be magnetised, the greater its coercivity, but this intrinsic particle magnetisation capacity depends both upon the properties of the magnetic stock (oxides or metals) and upon the shape of the particles in the stock in question, as well as on their clustering and arrangement on the tape.

The degree of coercivity which can be expected to be achieved in tape manufacture is also limited by the characteristics of the equipment used for emulsion recording and erasing purposes.

An emulsion's coercivity is also directly linked to its sensitivity, in other words, to the density at which the magnetic changes on the tape surface can be recorded and, therefore to the emulsion's capacity to record frequency ranges as wide as possible.

The signal/noise ratio depends upon many different factors, the most important of which are the regularity of particle shape and size and particle distribution throughout the emulsion, particle dimensions, no clustering and, lastly, tape surface irregularities.

Different strategies have been employed regarding two-layer tapes for the purpose of achieving progressively greater sensitivities and higher signal/noise ratios, each one of which entails major differences involved in the selection of stock and the manufacture of the emulsions.

2.232.11 - Emulsion Preparation and Magnetic Media Discontinuity Monitoring

Steel tape and wire crystals are clustered in a highly irregular way, which formerly lowered the quality of the recordings that could be made and gave rise to a marked tendency toward demagnetisation and high noise levels.

The first strategy employed for heightening two-layer tape coercivity, residual magnetism and quality was based on monitoring the discontinuity of the magnetic medium by creating a magnetic medium comprised of individual particles and making certain that all of the particles were of approximately the same mass and were arranged uniformly. This objective would require monitoring the shape and size of the magnetic particles in addition to their arrangement and grouping on the tapes.

The emulsion manufacturing process begins with the preparation of the magnetic particles, oxides or metals, the components of which are mixed and processed to achieve needle-shaped particles, the thickness/length ratio of which falls within the 1/5-1/10 range.

At the same time, the mixture of synthetic resins to be used as a binder is prepared. Up until the 1970's, the binders most often used were chloride and vinyl acetate copolymers, as well as other mixtures of thermoplastic stock, including cellulose nitrate. Heat-stable stock, mainly polyurethane, mixed with other epoxy, vinyl or polyester resins are currently used.

The ideal clustering mode is achieved by separating each individual magnetic particle from all the others.

During manufacture, the needle-shaped particles of the magnetic stock and the synthetic resin mixture are placed inside rotary devices (drums) in which, by means of different mechanical procedures, they are stirred until all of the metal particle clusters are eliminated and each particle is individually coated in a layer of binder.

The particle dispersion procedure is an extremely delicate process upon which many of the characteristics of the tape will depend. The presence of any particle clusters will give rise to irregularities in the emulsion coercivity, will increase the noise in the recordings and may even cause tape dropouts; on the other hand, if the resin thickness separates the particles too much, the magnetic capacity and the coercivity of the emulsion will be lessened.

F. 59: Development of a dropout in four sucessive images (Sample prepared by the Centro de Documentación de RTVE)

2.232.12 - Support Emulsion Application and Particle Distribution Monitoring

Once the proper dispersion has been achieved, the resin-particle mixture is combined with all of the other necessary elements (solvents, lubricants, antioxidants, fungicides, etc.) and is coated onto the support. This process is highly critical, and many different defects may arise therein, which may jeopardise tape quality and useful life.

The magnetic layer must be coated onto the support in a totally dust-proof environment once the tape has been meticulously cleaned. Any dust particles on the tape will lead to the formation of clusters and future emulsion dropouts.

On spreading the binder-particle mixture on the large rolls of support, an almost perfect monitoring of the emulsion thickness must be achieved. Any irregularities in emulsion thickness will lead to recording defects, and the tolerance margins stipulated for the sensitive layer thickness are ±2'5%. Layers uniform in thickness can be achieved using different approaches.

The binder mixture must include a solvent (generally cetones or dioxanes) capable of achieving solid adherence between the emulsion and support. This solvent must evaporate completely during the tape-drying process. Other protective elements may also be included, such as stabilisers of whatever polymers are used, plasticizers to increase the flexibility of the mixture or fungicides to safeguard the emulsions against microbiological contamination in warm, humid climates.

During the emulsion mixing and spreading process, the needle-shaped metal particles are pointing in all directions, but in order to achieve the highest coercivity and recording density levels, the needle-shaped metal particles must be physically pointing and aligned in one single direction.

For this purpose, while the emulsion is still "wet", an electromagnetic field is run over the tape to force the needle-shaped particles to turn unifying its physical alignment. This procedure results in the recording density being directly linked to the particle size, remarkably heightening emulsion sensitivity for high frequencies.

For audiotapes, the needle-shaped particles are positioned running lengthwise along the tape, although for some digital systems that require extremely high-density recording tapes, the particles are compacted and positioned vertically on the support.

For videotapes, the direction will depend upon the recording format for which the tape in question is to be used. Crosswise or spiral heads require very different directions, and achieving the exact direction for each format is an essential factor in tape quality.

On the sensitive layers comprised of vaporized metal, in order to achieve a granulated structure (providing individual magnetic fields for each crystal), given the high temperature at which this process must be carried out, the coating must be applied in several different coats.

The size of the metal crystals and their distribution on the supports are controlled by adjusting the support temperature and moving speed, as well as the dimensions of the surface area of the support exposed to vaporization and the concentration of the metal vapours in the high-vacuum chamber located in between the film and the melting pot holding the molten metal.

Due to the fact that layers of this type are comprised of regularly shaped crystals, the physical arrangement of the particles is of lesser importance than for non-circular layers. Nevertheless, by selecting the angle at which the tape is initially exposed to vaporization, the direction in which the granular crystal formations take shape can be controlled.

2.232.13 - Tape Finishing and Wear Control

Magnetic tapes run over the reading heads, videotapes coming into even closer contact with the heads than audiotapes. Therefore, in order for the tapes and heads to withstand this abrasion and for it to be possible for them to be used over and again, their surfaces must be strong and uniform.

Between the application of the emulsion and the cutting process, the large rolls (mattes) on which magnetic film is manufactured, are run through roller systems in which, due to the combined effects of heat and pressure, the tapes must come out completely smooth.

Lubricating products are added to the emulsion mixture to make it easier for the tapes to glide over the heads. Silicones have been being used for this purpose for audiotapes and, for a long time, also for videotapes, but the mechanical stress which videotapes must be able to withstand (i.e. when working frame to frame or when freezing the picture) has led to these substances being further improved adding natural oils to the composition of the emulsions.

Tape smoothing accuracy is absolutely essential in determining their quality. Tapes with surfaces which have not been made smooth enough, will be abrasive and will damage the equipment heads, but tapes which are too smooth will not be capable of cleaning the heads and will lead to effects like glossing.
If magnetic particles or dust from the binder resins drop off, the reading heads may become fouled and lose their sensitivity or build up debris which may be damaging to the tapes proper.

On causing differences in the contact between the emulsion and the reading heads, surface irregularities may give rise to another two effects of greater importance for recording quality, that is, they lower the high frequency response capabilities and increase noise when reproducing the recordings.

To reduce the static charge of tapes and to prevent slipping during rolling, for some types of tapes, the back side of the support is coated with a layer of carbon (graphite) particles clustered in a synthetic resin.

2.24 - Recording and Magnetic Tape Degradation

Magnetic recordings may undergo negative changes if they are exposed to the effect of electromagnetic media or if they are subjected to mechanical strain or to improper temperatures and, of course, may be erased for reuse.

Recordings being accidentally altered are not something which can easily happen. Electric motors, the electromagnetic components installed in different equipment, high tension wires and even some smaller equipment, such as fluorescent bulb starters, are elements which can create fields capable of altering or erasing a recording, but in order for this to be possible, these elements have to be located very close to the tapes, and avoiding such positioning in archives is not highly complicated.

The influence which these fields can exert on a certain area of the recording, in particular, on the particles of the neighboring loops, is rather a complex problem which is especially serious as regards audio recordings and large-sized 1"-2" video reels. In this process, known as "induction copying" or "print through", the arranged particles on one area of the recording act on the disarranged particles on the neighboring loops, pointing them in their same direction and creating echoes which muddy the recording on the loops in question.

This effect takes place very slowly and will be worse the tighter the loops are wound, depending upon how thin the support stock is and on how long the tapes are not in use. Regarding tapes wound inside cassettes, although they are very thin, the looseness with which they are wound lessens the scope of this problem, and digital recordings are apparently not affected at all.

F. 60: Magnetic perfored film with triactetate base, severally damaged by the vinegar syndrome.

The possibility of reusing tapes for other recordings is, indeed, one of the most serious problems involved in the preservation of Audiovisual Patrimony. In all sectors, but more especially in countries or at companies having financial limitations, the economic cost of tapes is directly conducive to their being reused, a major part of the original audio and video recordings hence being lost forever.

Laboratory practice and experiences have proven metal ions to catalyse the chemical degradation of acetate supports. This is a particularly serious problem with regard to the magnetic recordings used in classic filmmaking, both for the perforated magnetic film used in sound track production and for those prints incorporating adhered magnetic tracks.

At present, the preservation of these types of films on their acetate supports is highly problematical, given that the extreme measures which can be taken to prevent the degradation of the acetate supports (frozen storage at very low relative humidity levels) may apparently be damaging to the stability of some of the emulsion components.

PVC and polyester supports seem to provide more satisfactory stability.

High temperatures and high relative humidity are conducive to corrosion by way of the oxidation of some of the oxides used in the emulsions, apparently especially chromium dioxide emulsions.

Some of the alloys used in evaporated metal tapes are also sensitive to the combined effect of humidity and oxidation. Corrosion causes emulsion drop-out, may damage the supports and may also make the tape more abrasive, leading to excessive wear on the reading equipment.

The polyurethane copolymers in the emulsions are broken down by way of a number of complex oxidation and hydrolysis processes which are also set off as a result of high temperatures and high relative humidity [83].

Chemical degradation is damaging to emulsion consistency, meaning that the emulsion may be damaged on running over the reading heads. Over the course of time, the emulsion particles which drop off and adhere to the reading heads causing even further damage to the emulsion.

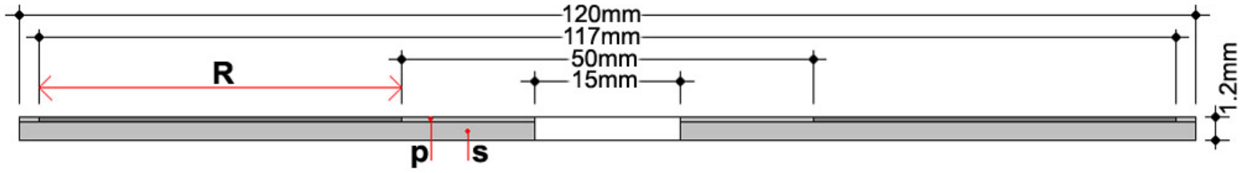
83 Michele Edge: "Aproaches to the Conservation of Film and Sound Stocks". In: *Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000.*

2.3 - Optical Disc Sensitive/Reflective Layers

For optically-scanned discs, the sensitive layer concept must be understood as referring to two different elements which are incorporated into the disc or handled separately, that is, the plastic layer on which the information is recorded and the metal layer which reflects the laser beam back to the reading assembly.

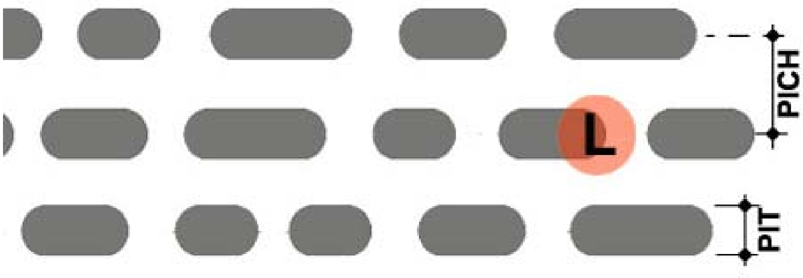
2.31 - Disc and Recording Structure

The information is recorded forming a concentric spiral (from the inside to the outside of the disc, in a clockwise direction), which is done on a 12.5 mm- 58mm radius.



F. 61
Standardized formats for digital optical disks.
[R] Recording/reading area. [s] Polycarbonate base. [p] Acrylic protection layer.

The recording pits are comprised of lengthwise marks (in the direction of the spiral) which modify the reflected light. On die-stamped discs, these marks are comprised of pits (bumps, when viewed from the laser scanner position) made directly on the polycarbonate layer of the substrate/support; whilst on the live recording discs, the marks are made using heat to burn a plastic layer located on the metal reflective layer.



F. 62
Basic formats in the recording structure of the digital optical disks (vary according to the systems and recording formats). PIT: width of the recording point. PICH: Separation between two consecutive tracks. L: Laser bean focus.

The characteristics of the plastic layer on which the information is recorded differ completely between die-stamped discs and direct recordings.

- Stamped recordings are stamped on the polycarbonate substrate proper.
- Direct recordings are recorded on a plastic layer the transparency of which can be permanently altered (CR-R and DVD-R) or the transparency of which can be restored by means of another heating process for re-recording purposes (CD-RW and DVD-RAM, DVD-RW and DVD+RW), the plastic stock employed and the structure of this layer varying depending upon which system is used.

On die-stamp discs, the reflective layer is usually aluminium, whilst it is usually gold or silver (or gold or silver alloys) for direct recording discs, this layer measuring 0.05-0.1 µm in thickness.

The protective layer is usually made of different types of acrylic plastic in 10-30µm thicknesses. An identifying label measuring 5-10µm in thickness may be placed on this layer.

On the direct recording discs, the burning layer may be made of phthalocyanine, cyanine, metal-azo or of other different substances which will also vary in thickness depending upon the system and the brand in question.

The track pitch and the size and spacing of the recording pits differ depending upon the system on which the disc is to be used.

On CD-Rom and CD-Audio discs, the track pitch is 1.6 µm. The marks are a maximum of 0.5 µm in width and can run along lengths of 0.833-3.054 µm.

On current pressed DVD discs, the standardised dimensions are much smaller. The track pitch is 0.74 µm, and the marks can run from lengths of 0.4 µm.

For current DVD discs, there are systems which record one single layer, systems with a layer for each side of the disc and systems with two layers on one same side. The number of layers will be reasonably certain to increase in the future.

2.32 - Optical Disc Degradation

Currently existing studies prevent the possibility of venturing any reliable hypotheses with regard to the durability of these supports.

All of the manufacturers make mention of useful life figures of over 100 years for their supports (in some cases, they have gone as far as to venture figures of 217 years and up to 500 years), but these studies do not seem to be reliable and, in any event, are much longer than the maintainability which can be guaranteed for the currently-existing equipment, systems and formats.

Polycarbonate is highly sensitive to light (ultraviolet rays alter its surface consistency), and the aluminium reflective layer is also very light sensitive.

The optical disc system is highly resistant to normal mechanical damage (scratches). The laser is focused on the reflective layer, and any minor flaws on the disc surface will be outside of the focal point and will not noticeably alter the scanning. The yellowing of the polycarbonate due to the effects of the light will not give rise to any serious problems either as long as these effects are minor.

At the Joint Technical Symposium held in Paris in January 2001, several different studies were presented having to do with the conservation of recordings on CD and DVD supports [84]. These studies analysed the deterioration of the supports - under the effects of air pollution, sunlight and heat as related to the increase in the block error rate (BLER), which seems to be quite an appropriate system for weighing the true durability of these recordings.

Although these studies were not concluded, they show that the aluminium layer is sensitive to air pollution corrosion and that all of these supports are deteriorated by light and heat, in addition to having revealed (as was to be expected, given the characteristics of the recording system in question) that the number of errors detected rises much faster on the direct recording discs than on the stamped discs.

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84 *Joint Technical Symposium, Paris 2000. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000.* See: (p. 75-75) Léon-Bavi Vilmont (C.R.C.D.G., France): "Effet des polluants atmosphériques sur les disques compacts"; (p. 104-112) Jacob Trock (The Royal Danish Academy, Denmark): "Permanence of CD-R Media"; (p. 113-127) Jean-Mark Fontaine (BnF - U. Paris 6 - CNRS, France): "Éléments de caractérisation de la qualité initiale et du veillissement des disques CD-R"; Peter Z. Adelstein (I.P.I., Rochester, USA): "Update for Standards for Information Preservatión".

As has been mentioned in the first paragraph of this section, it is not as yet possible to set any lifetimes of use for this stock, but empirical (and possibly reliable) observations made by professionals who use DVD supports for the back-up copies they make for their work indicate that, for the rewritable DVD's currently available on the market, the acceptable block error rate limit is exceeded when these discs are around two years old.

The criteria that can be used for support and emulsion classification are relatively simple and, in general, to classify them properly, the data available by way of visually inspecting each stock and knowledge of the history of motion picture film manufacture will suffice.

Supports and emulsions are classified based on three types of identification:

- The plastic stock used in the support
- The type of emulsion
- The brand and type of stock

2.41 - Support Plastic Identification

There are different procedures for identifying celluloid supports. For identifying other types of plastic supports, there are practically no other ways than laboratory chemical analyses. However, knowing what safety plastic is used as the support for each film, can be important for conservation-related purposes.

The need of separating nitrates from acetates came into being (even outside archives) for obvious public safety-related reasons. Later, it would be discovered that it was totally necessary to separate nitrates from acetates, even if celluloid had not been flammable. The gases given off by nitrates (even during the "inert" stage of degradation) seriously affect acetates.

Similarly, the possibility must be taken into account of the by-products of the degradation of each safety plastic having the effect of causing the degradation of other plastics.

In addition to the above, setting up systems for identifying the plastic stock used in each film may be a highly profitable pursuit for monitoring conservation on a statistical basis and, if necessary, for reorganising collections or revamping storerooms.

2.411 - Chronological Aids for Support Classification

Although the background history of the initial marketing and taking off the market of the plastics used in supports is an unclear and not very well-known - and although it involves different aspects in almost every country - this background can be of major help for classifying supports or at least for providing some guidance with regard to the attention which must be paid to identifying the plastic used in each film and each stock when they are being inspected.

Based on the fact that filmmaking first started out using celluloid supports, a number of stages can be defined.

2.411.1 - The Use of Diacetate

Kodak was the first to have attempted to implement the use of diacetate, for 35mm film, back in 1909. There is no data available concerning the extent to which this product was actually used.

According to Eric Loné, Pathé used diacetate in its 28mm "Pathé Kok". Nevertheless, films of this gauge (possibly produced by manufacturers other than Pathé) have been found to exist on celluloid supports.

The second stage of diacetate began in 1922-1923, when the 9.5mm "Pathé Baby" and Kodak 16mm films first came out. Many manufacturers, including Gevaert and Fuji, produced films of these gauges with diacetate supports.

In 1927, Pathé launched its "Pathé Rural", manufactured with 35mm diacetate supports that were cut into two 17.5mm strips once developed.[85]

Kodak may possibly have used diacetate (in conjunction with acetyl-propionate) for its 8mm films first launched in 1932 on 16mm supports.

There is no set date for the changeover to triacetate supports for all these types of film, which must have taken place gradually throughout the 1945-1955 period.

No nitrate supports for 9.5mm, 16mm or 8mm films have been found to exist.

2.411.2 - The Use of Combined Esters

W.E. Lee and C.C. Bard[86] mention that Kodak used acetyl-propionate in the 1930's for slides and reversal colour films for amateur photographers (possibly "Kodachrome"). In the Kodak document "KODAK Colour Films for Instrumentation", published in 1980, it is stated that the "Kodachrome 25 Control Film - 7267" stock was still being manufactured on this support at the time. There is no other data related to the continued use of this support or to the products for which it was used, although Lee and Bard note that it was not used for professional supports.

Acetate-butyrate is listed in its catalogues Gevaert for 9.5mm and 8mm films and for 16mm films (for which it was used as a support for reversal, negative, positive and copying emulsions). Gevaert also used this plastic as a safety support for some types of film for 35mm prints, which were also manufactured on nitrate supports at the same time. In 1956, this plastic was taken out of the catalogues.

2.411.3 - Start of the Use of Triacetate/ End of the Manufacture/Use of Celluloid Supports

Biphenyl phosphate plasticized triacetate first started being manufactured in 1941. Prior to 1945, it was used to some extent in 16mm films in the United States.

Kodak first began using triacetate for 35mm films after 1945.[87] Gevaert started using triacetate in 1952, Ferrania and Agfa in 1953, Fuji having changed over all its products to triacetate in 1958.

The production lines for celluloid for use in film started being shut down in 1950. Around 1952, Kodak was no longer manufacturing celluloid, which would stop being used as a filmmaking support in Europe and in the U.S. around 1954. Celluloid continued to be used in Japan up until 1958 and in China up until the early 1960's.

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85 The 17.5mm width, but with a center row of perforations (similar to 9.5mm film) with celluloid supports had already been manufactured by Emermann and other manufacturers during the very first years of the 20th century.

86 W.E. Lee y C.C. Bard: "The Stability of Kodak Professional Motion Picture Film Bases". In "Image Techonlogy", December 1987, BKSTS, London, U.K.

87 Lee and Bard give 1948 at the date on which 35mm first started being manufactured in the aforementioned article.

The end of the use of celluloid supports is the most controversial aspect of this part of filmmaking history and may involve some major differences according to each individual country and film studio.

Based on the existing records, the initial use of safety supports for 35mm films can be approached from the standpoint of three different stages:

- Use in Release Prints

Starting back in the 1930's, the attempt was made in different countries to set up regulations to regulate or prevent the use of flammable supports for public movie theatres, these initiatives not having met with great success until the industry accepted the use of triacetate supports for their 35mm productions. In this environment, release copies would be the first type of stock produced totally on non-flammable supports.

The study of laboratory documentation, in conjunction with the analysis of the stock recovered, makes it possible to say that, in Spain, the changeover from nitrate to triacetate took three years (1952-1954), and that practically no flammable copies were found to exist as of 1953.

It must be taken into account that a film could have been distributed in any one country on safety supports and on flammable supports in some other country. It must also be noted that the copying rates have varied greatly, it being perfectly possible at that time, for example, for premiere release copies of a film to be produced on nitrate and subsequently on triacetate in later years.

The archives must study the specific situation in each individual country and almost each print of the transition period.

- The Use of Negatives and Dupes

For some time, flammable and safety stock could both be used in the negative of the same film. This was so for two reasons:

- The flammable negative stock on hand in the warehouses of the manufacturers and their regional distributors or those of the film studios proper.

- Many manufacturers having made changes in the characteristics of their films (not always successfully) at the same time as changing the support used. These changes led to some photographers having continued to prefer the earlier stock as long as it continued to be available.

Films have also been found which were filmed at the end of the transition period in which the only flammable stock in the negatives was, for example, one single scene filmed on a certain location in particular, for which a batch of stock left over from previous shoots might have been used.

As far as the sound and dupe negative are concerned, evidence exists of safety supports having been acquired as the stock on hand on the part of the raw stock supplier was progressively sold out. Generally speaking, for this stock, all of the rolls of a motion picture have been filmed one same type of support.

The greatest amount of confusion exists with regard to the copying stock used for the laboratory-filmed superimpositions and effects and the generic titles of movie theatre newsreels. For these types of stock, flammable supports have been found to exist even on dates outside of what is considered as being the transition period.[88]

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88 In Spain, the "Noticiario Cinematográfico NO-DO" (a government newsreel which which put out two editions weekly at the time), employed flammable dupes for the generic leaders of the news sections up to 1955.

- The Use of Secondary Production and Editing Stock

Regarding these types of stock, irregularity is the norm for the entire transition period, even running into post-transition years.

Flammable stock (i.e. synchronised music, dialogue or effects tracks) is commonly found in motion pictures for which the negatives, copies and other basic stock are completely triacetate.

Generally speaking, to appropriately distinguish flammable supports from safety supports, the archives must base themselves on study and defining, on statistically sound bases, those periods during which this transition took place in the areas from which each stock comes, considering that all of the stock of the motion pictures filmed prior to the end of the transition period must be carefully examined.

This examination must be made at least roll by roll for the motion pictures filmed during the transition period; and for the negatives, for the secondary production stock and for well-used copies (which may have been pieced together by the distributors from several different copies), this examination must take in each one of the elements spliced into the film.[89]

It is highly important that the archives do not confuse the period in which the nitrate-to-acetate transition took place in their own country with the period in which this same transition took place in the country where each stock was manufactured. Major time-related differences exist, for example, between the transition period in Europe and in Japan.

2.411.4 - End of the Use of Triacetate in Perforated Films with Magnetic Emulsion

This is an extremely irregular period. It can be said that the transition to polyester took place throughout the 1960's. In the early 1960's, all of the manufacturers were marketing their products on both types of support, and around 1976 most perforated magnetic films were being produced on 125-micron or 75-micron polyester supports.

However, the reusing of discarded image film as continuity elements in synchronised music, dialogue or effects tracks continued well up into the 1980's.

Initially, triacetate supports were also used in some two-inch video tape.

2.411.5 - The Advent of Synthetic Plastics

Although there may be some exceptions, triacetate supports for audiotapes progressively stopped being used during 1960's.

In audio and in video, up to the dissemination of the biaxial polyester stretching systems, the PVC supports managed to compete with polyester supports. No studies have been published as to the implementation of each one of these supports in the 1960's and 1970's.

For photochemical films, the use of polyester was started by Fuji around 1965 for its Single 8 films, soon after which Kodak would bring out its Super 8 films. Starting in 1972, different manufacturers started marketing professional products with polyester supports (products which were also being marketed in

89 The small bits of transparent film (1-2 frames) which were inserted into many negatives for final image-sound synfhronization purposes may be made of a nitrate stock up to several years following the transition period.

triacetate at that same time), but these products were not marketed on a widespread basis until twenty years later.

In the 1990's, polyester supports took over the conservation master market and became the type of support used most in all other types of film.

2.412 - Celluloid Support Identification Options

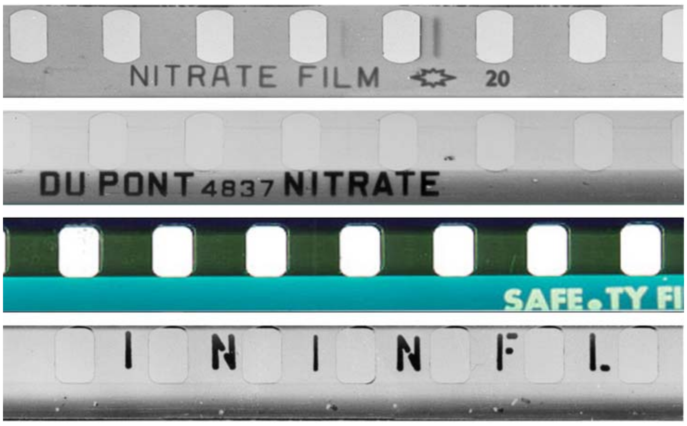
Film manufacturers and archives have come up with some more or less simple, reliable procedures for distinguishing celluloid supports from all the rest.

2.412.1 - Manufacturers' Identifying Marks

Starting in the 1920's, as diacetate supports progressively gained popularity in small-gauge films, some manufacturers made it a rule to identify the type of support involved by stamping latent image inscriptions on the film (such as: "Nitrate", "Nitrate Film" or "Safety", "Safety Film, "noflam" or "ininf") located on the outer edge of the film every certain number of frames.

Each manufacturer adds these marks based on their own individual criteria. Some did not add them to their products, some marked solely the safety films, whilst others added none whatsoever.

These markings are very useful with regard to providing us with an idea as to the type of support, but it must be taken into account that they may be copied from the original stock.



F. 63: Identification of the support. Marks: 1. On a negative Kodak. 2. On a duplicate Dupont. 3. Reproduced from a negative Kodak. 4. On a print Mafe.

F. 64: Mark of a flammable original reproduced on a security print.

Contact printers also copy the markings located on the film edges due to the fact that some of these markings (i.e. the consecutive footage numbering) are absolutely essential for linking the editing of the film to that of the negative.

More often, safety supports are encountered which have marks copied from their flammable originals. It is also possible (although much less frequent) to find flammable supports bearing markings corresponding to safety negatives.

2.412.2 - Ultraviolet Fluorescence

Some safety films manufactured by Kodak incorporate a minute amount of reagent into the triacetate mass which is sensitised - and shines- when the roll of film is held in front of an ultraviolet lamp.

This practice has regrettably not been continued at all or solely for some products in particular by the rest of the manufacturers, its effectiveness for identifying stock as diverse as those which come into an archive therefore being highly limited.

F. 65: Ultraviolet fluorescence
(Image taken from "The Book of Film Care", Eastman Kodak Company, Rochester, USA, 1983)

2.412.3 - Differing Densities

Different FIAF Preservation Commission publications present a technical detection system based on the existing differences in density between nitrate (heavier) and acetate.

In this system, two samples of nitrate and acetate (i.e. two small circles measuring 5mm/6mm in diameter) are placed on the surface of a container holding trichlorethylene (a toxic liquid of a density lighter than nitrate and heavier than acetate). The nitro-cellulose sample sinks, whilst the acetate sample floats.

Achieving proper repeatability for the results of this test may be highly difficult. The differences in density which may exist among different types of acetate, as well as the control-related requirements as regards the air temperature and pressure conditions and the moisture content in the samples, all combined, may lead to the resulting findings not being highly reliable.

2.412.4 - Electrical Conductivity

Nitrates and acetates differ with regard to their electrical insulating capabilities. It has many times been suggested that these differences be used for determining the plastic nature of films, but the existing variations in thickness among the stock produced by one manufacturer and the other (and even among products of one same brand which have been manufactured in different years or at different plants) masked the actual conductivity of the plastic, the thicker nitrates being positioned in areas which would theoretically be those where the acetates should be found.

2.412.5 - Burning

Although different researchers due to its highly limited degree of efficiency and its destructiveness have ruled out the burning test, this test is the clearest-cut and fastest for identifying flammable supports.

The criticism concerning this test's highly limited degree of efficiency must be considered, at the least, superficial and lacking sufficient depth. The characteristics of the flame with which celluloid burns and the flames given off by safety films can be completely well distinguished from one another based precisely on the chemical properties of the burning processes of these two types of stock:

- Nitrates burn fast and require no outside sources.
- Acetates burn slowly and require the presence of outside oxygen.

Apart from the above, the plasticizers used in processing both of these plastics contribute, even further, to heightening these differences.

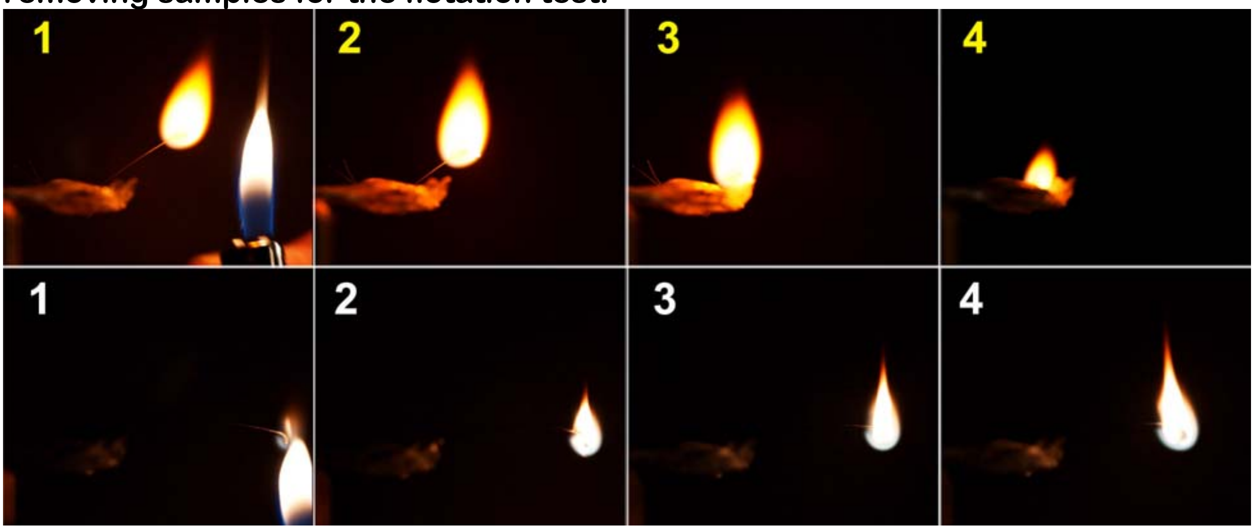
The criticism related to the destructive nature of this test is even less understandable.

The proper procedure for conducting the combustion test begins with taking the sample, a very thin strip of stock, measuring only a few tenths of a millimetre in width and one or two centimetres in length, clipped from the film edge.

F. 66
Size of the samples necessary for the combustion test (in centimeters)
(Photograph: Diego Martín).

Removing these strips weakens the film much less than procedures such as notching to mark the changes in light that is used in many grading systems. Nevertheless, the preparation of the samples requires a certain degree of skill and training, it being desirable for the technicians to repeatedly practice on films which are no good before taking any actual samples.

In any event, especially when dealing with rolls comprised of different brands or types of film, which must be examined section by section, much less stock will be destroyed by conducting this test than by way of procedures such as removing samples for the flotation test.



F. 67
Four stages of the combustion of a sample of nitrate (above) and other of triacetate.
(Photographs: Diego Martín)

For conducting this test, the samples are held by one end (tweezers may be used, but are not necessary) and are ignited. Naturally, this part of the test must be conducted far enough away from any potentially flammable stock.

The flame resulting from the burning of the celluloid samples will be, in all cases, of the following characteristics:

- Fast burning, at uniform rate of speed.
- Volume (of flame) proportional to the cross-section of the ignited strip.
- Regular shape, approximately spherical and pointed upward (teardrop-shaped)
- Yellow colour, uniform over the flame's entire outer surface.
- If the volume of the sample so allows, small dots of fire, like sparks, may occasionally be seen coming off the flame surface.
- Due to the temperature at which the burning takes place, the ashes break up and scatter without leaving any noticeable residue.

The burning of the acetate samples (which normally burn, it therefore being highly important for the samples to be as thin as possible) will give rise to many different flame types which are, in no case, similar to the nitrate flames, which, within their possible range of differences, will be of the following characteristics:

- Fast, yet irregular burning. They may even go out.
- The flame size is not proportional to the cross-section of the sample, varying even during the burning of one same sample.
- Irregular shape, with variable "bulges" (dripping in appearance) at the bottom and fluttering at the flame tip.
- Yellow and blue colouring, of different shades, distributed irregularly depending upon the convex surface of the flame.
- Presence of cohesive ash (ash not scattering into dust).

F. 68 - Samples of nitrate (left) and triacetate burning simultaneously.
In order to obtain this effect, it was necessary to use a bigger sample of triacetate. (Photograph: Diego Martín)

2.413 - Distinguishing Among Safety Supports

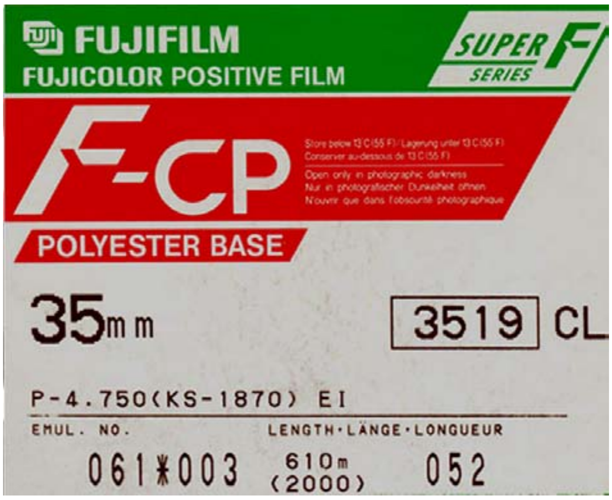
As previously mentioned, other than the destructive chemical tests which can be conducted in a laboratory environment, no other methods exist for identifying the different safety supports. Therefore, the only way of approaching this problem is often that of going by and further expanding upon the chronological criteria previously provided in this document by adapting these criteria to each individual country in question.

Gevaert first used the latent image "AB" abbreviation on some of its acetate-butyrate supports, and some manufacturers are currently adding codes identifying the plastic used on their edge markings. Nevertheless, manufacturers do not generally mark the type of plastic used on their films.

In most cases, identification of the plastic used in the manufacture of the film is provided on the raw stock containers, either directly or because the manufacturer uses specific codes or names for the films manufactured in each type of plastic.

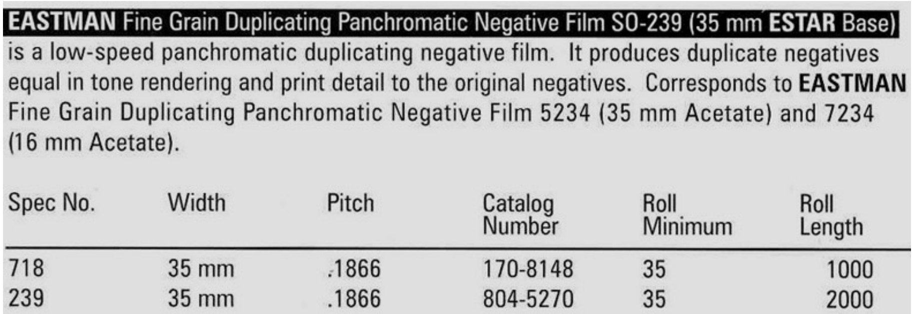
Regarding modern stock and, whenever possible, regarding earlier stock, the archives must take note of the characteristics of the supports which are provided on the raw stock containers. These containers are usually re-used for the films after copying and are very often received by the archive with the original label covered up by a laboratory label [90].

Other valuable data may also be found on many laboratory invoices and delivery notes (receiving orders) and, at some archives, in the administrative and maintenance files which are kept on each stock.



F. 70. Label of a film Fuji with polyester base.

F. 71. Identification of the type of base through the manufacturer's catalogue.



EASTMAN Fine Grain Duplicating Panchromatic Negative Film SO-239 (35 mm **ESTAR** Base) is a low-speed panchromatic duplicating negative film. It produces duplicate negatives equal in tone rendering and print detail to the original negatives. Corresponds to **EASTMAN** Fine Grain Duplicating Panchromatic Negative Film 5234 (35 mm Acetate) and 7234 (16 mm Acetate).

Spec No.	Width	Pitch	Catalog Number	Roll Minimum	Roll Length
718	35 mm	.1866	170-8148	35	1000
239	35 mm	.1866	804-5270	35	2000

Trying to identify the standard for determining this item of data for all of the safety stock kept in an archive may be too huge a task and impossible to encompass. Nevertheless, investing a minor effort in identifying the plastic stock during the acceptance inspection of each new stock is something which all archives should consider doing, which may pay off greatly in the end for film preservation purposes.

2.42 - Film Classification by Emulsion Type

Firstly, the "emulsion type" concept has to do solely with the use for which the film has been designed within the copying chain and encompasses B/W and

90 Since 1992, some manufacturers began to introduce numbers in the edges, identifications of the emulsion that allow the type of base to be established. See: Machine-readable BARCODE and human-readable edge information on 35mm and 16mm colour negative films, Agfa-Gevaert, 1994; and Números EASTMAN KEYCODE. Los números que cuentan, Kodak, 1992

colour emulsions as well as the negative→positive or reversal system emulsions. But the films for colour involve other problems that must be taken into consideration in the classification process which have to do with their colour ratio and to the standards accepted by the laboratories for the processing of triple-layer films with integral masking.

Setting up a simple classification system for films based on the type of emulsion employed should be useful for stock identification purposes and for assessing the characteristics of the images and sounds recorded thereon.

This classification is rounded out with those provided in Section 4.2 and Section 4.3, devoted to the generation-based identification of the copies and stock type classification.

In the archives, these identifications are made on films which have already been processed, which makes it unnecessary to deal with those characteristics which no longer exist following processing, whilst, at the same time, affording the possibility of using those which are added during filming and/or copying and editing.

2.421 - Film Identification According to Their Use in Reproduction

Achieving results meeting with varying success, one same film can be employed for different uses. Any film - positive or negative - will provide a negative image if it is used as camera film. The use of copy emulsions for copying purposes (even for making dupes) or to obtain of sound negatives has been done constantly during some filmmaking eras, and most of the reversal films can be processed to be used as negatives.

One basic classification might take in the following types:

- Camera films, which would encompass the camera negatives, the reversal camera positives and the sound negatives.
- Films for duplication, including the emulsions for positive and negative copying and the "intermediate" types which can be employed for any of the aforementioned uses, and the reversal emulsions for copying. Depending upon the archive's criteria, the Technicolor matrixes might also be included under this heading.
- Films for copying, which would include those used for the negative→positive system and the reversal copying films.

Based solely on the physical and photographic characteristics, it is not possible to identify the type of stock used in each case with a hundred percent degree of accuracy. Nevertheless, a number of criteria can be employed to provide for a reasonable degree of precision.

As of the acceptance of the standardisation of perforations (progressively in the 1930's), camera negatives usually have a BH (Bell&Howell) perforation, commonly known as a "negative perforations".

The DH (Dubray-Howell) perforation was suggested and used for negative and positive films.

Except in the early years, sound negatives have always been made on film stock which has the KS positive perforation.

Duplication films (which first came out approximately at the time when the perforation standards were first approved) have BH negative perforation.

Copying films have KS (Kodak Standard) perforation, commonly known as "positive perforation".

The main characteristic of camera film is that its entire surface outside of the image area is transparent (not printed). For these films, the ribs between frames and the perforation and edge bands are completely blank, except for the edge markings added by the manufacturer.

Nevertheless, it must be taken into account that printing films can be used in an optical copier camera and be of exactly the same characteristics; and that, additionally, a roll of this film being accidentally exposed to light before it is processed can add "images showing up" from the edge, the perforations or the footage numbering when they are inked on.

Except when made in optical printers, the duplicates and copies will have an image (that is, light-sensitised areas) outside the area of the frame image. These sensitised areas may simply be dark (opaque) areas or may have the edge marks of the previous stock or the inside edges of the perforations showing on them.

On the original image negatives, there are usually duplicated sections pertaining to leaders or to effects which are done by way of laboratory superimposition.

Even on the copies made using optical copiers, the edge of the image areas filmed on the negative and on the copy may not coincide, there being double (or triple) gate and frame setting marks.

Some of the stock for positive B/W duplication are bluish (lavender) in colour or are dark (brown), which are the dyes used by the manufacturers in the support. For triple-layer emulsions for colour with integral masking, the entire film has a uniform orange-coloured background.

"Intermediate" film is a colour stock with an integral mask which is suitable for use for copying positive or negative duplicates.

For B/W films, it was very common for combined image and sound duplicates to be made. Of course, any stock which contains optical sound and image cannot be a camera original. [91]

91 Except for the negatives of some of the first optical sound systems, such as the Tiergon or the first Movietone systems.

As of the full implementation of the sound editing system, each roll of a duplicate or copy had to be splice-free, with the exception of those splices made for arrangement or synchronisation purposes.

Separation films are a particular set of B/W negatives. For these films, by combining the use of filters with the colour-sensitivity of the emulsion, it is possible to separately reproduce the images corresponding to each one of the three basic colours. The identification of the range of the spectrum to which the image of the film reproduced corresponds can only be done in all certainty if the frames of the colour chart used by the laboratory have been preserved.

Reversal emulsions for duplication have fulfilled a major function in 16mm filmmaking. In principle, these emulsions were used for making copies in reversal colour systems and, later, with the introduction of reversal films with integral masking, they have also been used in the duplication process.

In 35mm, the Kodak "Colour Reversal Intermediate" (CRI) emulsion was used for the direct duplication of original negatives.

For electronic sound and image recordings, a different classification must be made which does not take in the negative→positive concept.

- Magnetic emulsions, encompassing perforated magnetic films and "smooth" magnetic tapes and, depending upon the conservation criteria of each individual archive, the image films equipped with magnetic tracking.
- Optically-read discs, including stamped discs and writable and rewritable discs and, also depending upon the criteria of the archive in question, the stamping dyes.

2.422 - Film Classification by Colour Relationship

In order to achieve a complete classification of the colour ratios which the films kept in an archive have, we must be aware of:

- The existence, or not, of colour in each material and in the film the materials belong to.
- The system used to reproduce or introduce the colour, according to the criteria exposed in the section 2.14 and 2.15

2.422.1 – Photochemical supports

1. B/W films
    - Negative, positive and reversal films
2. Prints coloured by hand on B/W emulsion
    - copies coloured by hand or by means of stencilled
    - copies tinted or varnished
    - copies toned in one colour
    - copies with the combination of the two anterior systems.
3. B/W films for reproducing in colour
    - B/W negatives and copies for screening with filters (Kinemacolor type systems)
    - B/W separation negatives for reproducing on toned B/W emulsions (Dascolour and Cinefotocolor type systems)
    - B/W separation duplicates and negatives for obtaining Technicolor matrixes and Gasparcolor copies
    - imbibition matrixes for Technicolor

- B/W negative duplicates for reproducing on triple-layer emulsions for colour using the possibilities of the lamphouse of the printers (Desmetcolor system).

4. Films in colour-additive systems
   - additive mosaic system reversal films (reversal type Agfacolor, Kodacolor or DufayColor)
   - DufayColor system positives and negatives.
5. Films in colour-sustractive systems obtained by separation negatives or duplicates
   - Technicolor colour copies.
   - Copies reproduced with toned B/W emulsions (Dascolour or Cinefotocolor type)
6. Triple-layer colour films
   - reversal positives for colour (Kodachrome type)
   - negatives in systems without integral masking (Agfacolor or Gevacolor type)
   - reversal colour positives (Ektachrome type)
   - triple-layer reversal films for duplication with integral masking (type CRI)
   - triple-layer colour negatives with integral masking (Eastmancolor type)
   - triple-layer colour copies (Eastmancolor type copy).

2.422.2 – Electronic image

For electronic systems, this classification is similar to the relationship which exists between the luminance and chrominance signals and is detailed in Section 3.142 among those devoted to electronic image systems and formats.

2.43 - Classification by Brand and Type of Raw Stock

In some aspects, this classification rounds out the two previously discussed above and, in many cases, may be the only way of determining them in all certainty.

The characteristics of the films used in the filmmaking industry - and those of the images and sounds which can be reproduced with them - have undergone continuous changes throughout motion picture history.

Despite films being the filmmaking industry's stock and trade, the properties of the films which the industry has used for creating its motion pictures are not as yet known in sufficient depth. The studies made concerning film characteristics are relatively few in number and, independently of their quality, do not allow the setting out a systematic account as to how these characteristics have progressed throughout the past. Additionally, it is regrettably not easy to locate the technical documentation which would allow the making of these studies.

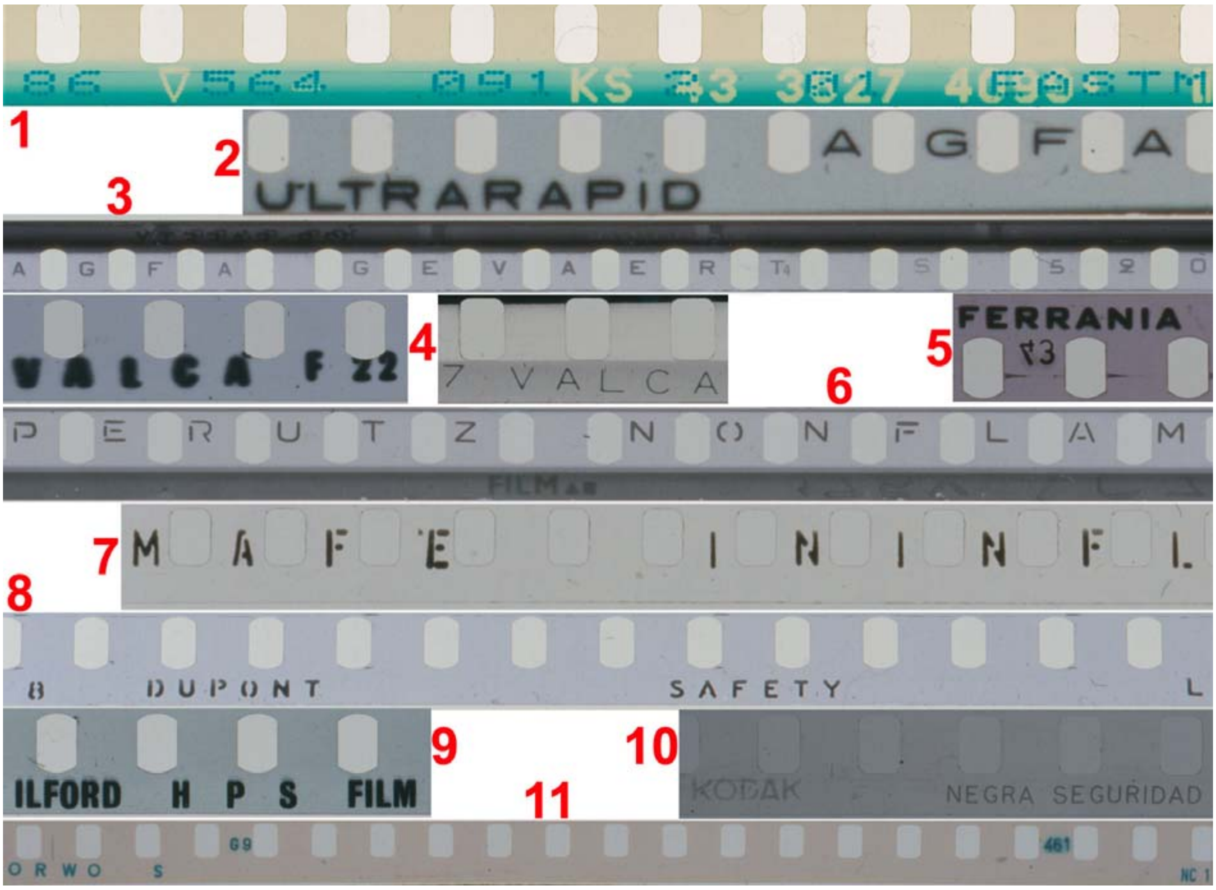
Determining the brand of any type of raw stock used in each reproduction can not only provide useful information concerning the photographic characteristics of the images, but may also be an irreplaceable tool for ascertaining the generation-related situation of the stock, and may also provide valid information for identifying the film.

Harold Brown, the head of the National Film and Television Archive (B.F.I.) laboratory and a leading member of the FIAF Preservation Commission, published a highly valuable pioneering study titled "Physical Characteristics of

Early Films as Aids to Identification" (FIAF, Brussels, 1990), in which he sets out in detail come of the elements which are found on the stock which can be used for identifying films.

In conjunction with some texts published in trade journals, the technical and commercial publications put out by the raw stock manufacturers proper comprise the main sources of information on film characteristics.

The FILM [c] database, which was initially started on the occasion of the F.I.A.F. Congress held in Madrid, is including this technical information published by the film manufacturers. [92]



F. 74

[1] Print Eastmancolor from negative Eastmancolor. [2] Negative Agfa Ultrarapid. [3] Duplicate AgfaGevaert, obtained from a duplicat and a negative Gevaert. [4] Negative and print Valca. [5] Negative Duplicate Ferrania. [6] Negative Duplicate Perutz obtained from a negative Kodak. [7] Print MAFE (emulsion of type Perutz). [8] Negative Dupont (n°8 and letter “L” indicate the type). [9] Ultra rapid negative Ilford (used in the sixties). [10] Print Negra, obtained from a positive duplicate Kodak. [11] Negative Orwocolor, manufactured since 1963. (Images obtained from a study carried out by Encarnación Rus and Jennifer Gallego)

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92 The Technical Workshop of the F.I.A.F Congress which was held in Madrid in April 1999, served as a launching pad for a project aimed a contribution to the knowledge of the history of the manufacture of raw stock for the filmmaking industry. The committee preparing the Madrid Project was initially comprised of Alfonso del Amo, Noël Desmet, Michael Friend and Hisashi Okajima and by the members of The Gamma Group of European Film Archives and Laboratories, with the additional support of the F.I.A.F. Preservation Commission.

Filmoteca Española published (January 2004) the initial version of the FILM[C] database, in which there is some documentation on film manufacture. This database includes a file for each one of the films and supplementary stock manufactured for filmmaking photography, in conjunction with another file on each one of the technical and commercial documents recovered concerning these products. This database also includes digitized reproductions of a selection of the most important technical documents.

CD-Roms of this database can be requested at Filmoteca Española.

In 1998, also as part of the work done in preparation for the Workshop at the Congress held in Madrid, two of the Spanish Film Archive's associates conducted a study aimed at determining what types of information could be pinpointed by means of analysing manufacturer edge markings.[93]

In a vast majority of cases, the edge marks placed on the films identified the trade name used by the manufacturer and indicated whether the support was flammable or a safety support.

More than half of the films included data regarding the stock's photographic characteristics (i.e. "ultrarapid", "panchromatic") or its manufacture (i.e. the jumbo roll or strip numbers).

In many cases, the data indicated the exact type of film (i.e. "Ilford HPS"), although this identification was sometimes disguised in code form (published by the manufacturers in their commercial documentation). Therefore, for example, Gevaert used a letter code (placed in front of the footage number) to identify the type of film, and Kodak similarly used letters and symbols to provide its data regarding the type of film or the year and country in which it had been manufactured.

In the course of said study, many films were also found to completely lack any type of identification whatsoever.

Generally speaking, the edge marks provided by the manufacturers serve the purpose of the product control needs on the part of the manufacturers proper and of their direct users, that is, producers, laboratories and photographers. These markings are usually extremely brief, the use of codes which have not been standardised being quite frequent. [94]

Due to these characteristics and to the fact that the studies conducted on this subject are still as yet few in number, fully identifying films by means of their edge marks is still highly difficult.

Nevertheless, looking for, taking note of or copying down these marks when inspecting each stock takes very little time to do and may being highly useful for classifying, conserving and restoring films.

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93 Encarnación Rus Aguilar and Jennifer Gallego Christensen: "La catalogación de las marcas marginales como medio para la identificación y conservación cinematográfica". In "Los soportes de la cinematografía 1" - Cuadernos de la Filmoteca Española, Nº 5. Filmoteca Española, Madrid, 1999.

94 Manufacturers employ non-standardized keys and codes because they provide these identifying markings for their direct use by laboratory technicians and cameramen, who have access to the technical information on the films they are using at each given point in time.

3 - Recording and Reproduction Systems and Formats

Both photochemical and electronic filmmaking have used a wide variety of support and format systems for recording image and sound, this variety entailing the existence of different recording quality and access-related possibilities, but also a long list of compatibility and conservation-related problems.

The number of systems available on the market has increased as technology has progressively developed and as a result of the impact on society which the audio-visual medium has assumed, an impact which has multiplied the needs for its use.

The driving force behind new systems and supports coming out on the market, one after the other, has always been rooted in the attempt to conquer progressively larger segments of the audio-visual market.

3.1 - Incompatibility & Standardisation

Reproduction compatibility is one of the fundamentals of audiovisual conservation, but it is fully a commercial problem, regarding which the industry takes action depending upon its own, legitimate objectives, and concerning which the archives (or the international or individual governmental cultural agencies) have very little possibility of effectively taking action.

The combination of the economic grounds of many of the most important innovations and the technical possibilities and the social needs of audiovisuals has resulted in a whole mix-mash of incompatibilities and compatibilities. And all of the attempts at standardisation, regardless of how rational they may have been, have never met with any success without having been accepted by the dominant manufacturers in each sector.

The industry may accept the standardisation set out for a product for very different reasons, one of the most important of which is the degree of success with which the product may have met. Therefore, for example, 9.5mm, 16mm, 8mm or S8mm films were manufactured by many companies which accepted the standards implemented by the manufacturers/holders of the patents on the products in question.

The acceptance of standardiisations does not have to cover all aspects of a product. Kodak and Fuji unified all of the characteristics of their Super 8 and Single 8 films from the start, because doing so was advantageous for boosting the market for the sale of reproduced films, but they kept the raw stock cassettes/loaders incompatible. Similarly, the DVD manufacturers promoted the setting out of a standard for stamped discs (even having created the DVDforum for monitoring the compatibility of innovations), but they have not accepted the standardisation of rewritable DVD's, a product for which no dominant manufacturer has yet come on the scene.

The validity of a standard must be accepted by all of the sectors involved in the use of the stock, this acceptance meaning the economic expenses stemming from taking the new standard upon themselves being in proportion to the profits they expect to make. Stereophonic sound systems did not meet with success until the 1980's, because movie theatre owners were not willing to undertake the monetary investments involved in revamping their sound equipment. However, these same movie theatre owners had accepted the new panoramic image formats because the investments required for adapting their systems were much smaller.

In the electronic image recording systems field, throughout the first fifteen years they were marketed, all of the equipment was unified into the Quadruplex format, but this format, with its two-inch tapes, was not suitable for many uses and was solely accessible for somewhat larger-sized companies.

The requirement for lighter systems that would be less costly to operate as well as the demands of the amateur market opened up the way to many different systems and formats coming onto the market. This non-stop process of new systems being launched on the market, which started around 1970, has brought electronic image recordings to their current degree of development but, at the same time, has turned the conservation of these recordings into an almost unreachable goal.

3.2 - Gauges and Formats in the Photochemical Image Technology

Throughout the early years, while films were still less than 50 meters long, and there were no distribution circuits or permanent movie theatre establishments, each moving picture show owner (who, in many cases, were also the directors of part of their films) could adapt their equipment to take whatever films they received and could sometimes even adapt the films to their equipment.

The consolidation and internationalisation of the movie business made it necessary to standardise some film characteristics by setting some more or less compulsory standards for film and machinery manufacture which would make it possible for them to be used on a widespread basis throughout the filmmaking movie business.[95]

Although the standardisations issued by the different standardisation associations cover practically all of the physical and chemical aspects of the films and their conditions of use, the standards which have taken on greatest importance are related to film sizes (support width), perforation types and positioning, the features of the equipment feed devices in the equipment and, lastly, the relative positioning and dimensions of the areas set aside for image and sound in the copies.

Around 1909, filmmaking had consolidated the basic standard of quality for the moving picture business.

Acceptance of the 35mm standard became necessary because it was absolutely essential to have a common element to serve as a basis for organising marketing, and it continued because, for the sole reason of having being accepted as a standard element, the 35mm films conditioning the characteristics of all of the other types.

Before and after the acceptance of the 35mm standard, many other types of film came out, and even other ways of using 35mm film, aimed at achieving high photographic quality or at getting motion pictures into the home, scientific or

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95 Whereas the motion picture business did not move beyond the travelling film show level, the sale of copies was the most widespread system for the film business. Those working travelling film shows could make a living by showing one set of copies every day or every week and then moving on somewhere else for each new set of showings. Around 1905, as permanent establishments for showing films began to take hold, those showing these moving picture theaters needed to renew their films every certain length of time, and the rental of copies for a few showings became the definitive film distribution system.

semi-professional environments. Most of these types of film went by the wayside more or less rapidly, but for all those which managed to achieve a certain degree of presence on the market, systems were developed to make them compatible with 35mm which afforded the possibility of distributing copies of the professional films on the markets created by the new equipment.

3.21 - Gauges & Perforations

The "gauge" concept refers both to the width of the film and to the space between the leading edges (pitch) of two consecutive perforations.

To indicate the gauge of a film, mention is usually made solely of the width of the support, given in millimetres. The existence of films having supports of the same width which have incompatible perforations makes it necessary to specify their gauges in further detail by using terms such as "8mm film" or "S8mm film".

3.211 - The Basic Standard: 35mm Films

In the summer of 1889, W.K. Laurie Dickson and George W. Eastman began a collaboration which would lead to the creation of a perforated film measuring approximately 35mm in width intended for use with T.A. Edison's Kinetoscope.

The Kinetoscope would be patented and launched with films on which 16 images/foot (304.8mm) were printed. This film had two rows of perforations, and each image was developed within a frame with four perforations on each side.

Auguste and Louis Lumière also used 35mm-gauge film starting as of 1894 for their work in creating the Cinématographe. The first films had two rows of round perforations and approximately 16 frames/foot. In the Lumière films, each frame had one perforation on each side, but just a few years later, first for the copies and later also for negatives, the Lumière brothers would accept the arrangement of four rectangular perforations per frame.

F. 76
Duplication of negatives with the Lumière perforation on film with the Edison perforation
In the image of the left, the duplication was made by surimposing the two films horizontally, underneath a glass. In the other image, we can observe how the film Lumière was reperforated in order to allow its duplication on a four perforations film.

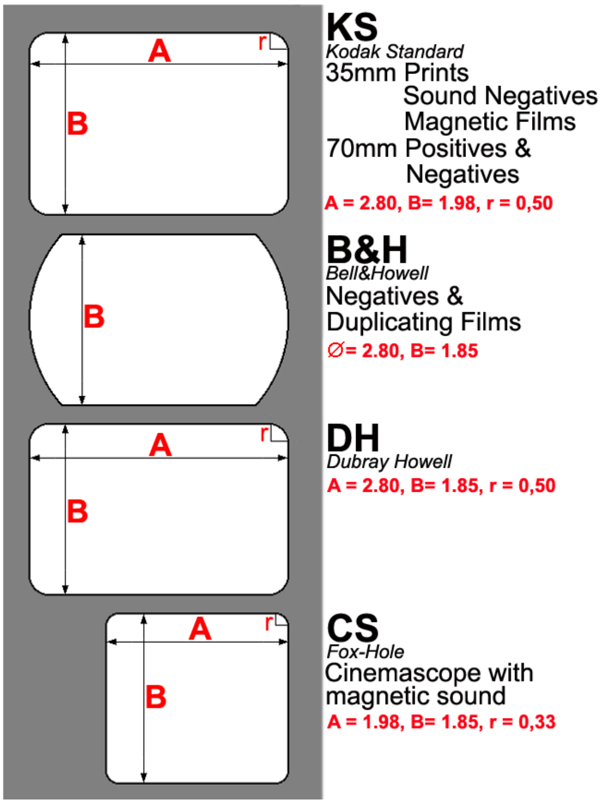
This 35mm film was used by other inventors and filmmaking pioneers. In some systems, such as the Joly-Normandin system, the perforations alignment was similar to Edison's, but each frame had five perforations on each side.

F. 77
Frame Joly-Normandin

The Lumière perforation having fallen by the wayside following the acceptance of a certain degree of standardisation for films, the following steps toward standardisation would not be taken until the 1920's:

Perforations varied in shape and size to a great extent. Each manufacturer and, in many cases, each laboratory, perforated their films using their own machines.

Basically, the perforations could be described as rectangular and were of two types. The first type, a spin-off from the Edison perforation, was a rectangle with four rounded corners; the second type, initially introduced by Pathé, was also rectangular, but the two short sides were curved.



The irregularities in perforation shape and size posed a problem with regard to marketing. In 1923, the industry approved two perforation standards, one for negatives and the other for positives.

The perforation proposed by Bell&Howell (BH), based on the Pathé perforation, was approved for negatives, the two curved sides of which are two segments of a circumference measuring 2.8mm in diameter. This perforation measures 1.85mm in height.

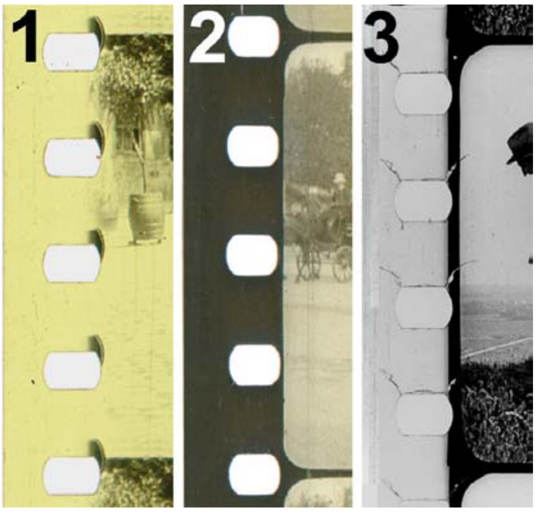
The Kodak Standard (KS), based on the Edison standard, measuring 2.8mm in length (same length as the negative) and a 1.98mm in height was approved for positives.

The standardisation of two types of perforations was based on the stability and strength-related needs which characterise films for filming and showing. The unrounded-intersection curved sides aid in providing stability for positioning the negative in the camera, and the greater heights and the rounded corners are much more suitable for increasing the strength of copies for screening purposes.

Nevertheless, for all other film pitches, solely one type of perforation has been used, and during the 1930's and 1940's, different attempts were made to abide by this same criteria for 35mm films.

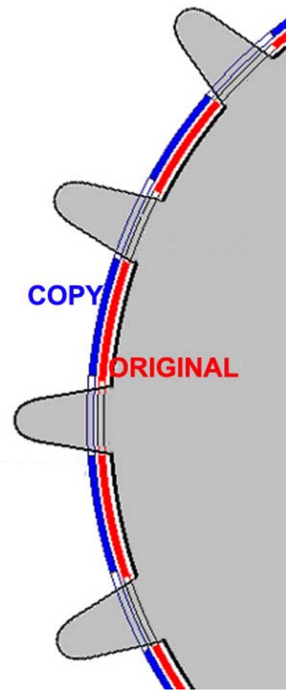
The Dubray-Howell (DH) perforation, similar in shape to the positive perforation but of the same height as the negative perforation, was approved as a unified perforation by some Eastern European manufacturers, this perforation however not having met with the approval of the U.S. and Western European manufacturers.

Yet another new type of perforation would come out in the 1950's, that is, the Fox perforation (Foxhole), which was much smaller, almost square and had rounded corners, being intended for used for the copies of the first CinemaScope which had four magnetic tracks. This perforation was standardised (AC perforation) measuring 1.98mm in width by 1.85mm in height.



F. 79: Standardization of the frame position in 35mm
Until 1923, the position of the frame line between two frames could vary from being centred on the axe of the perforation [2], or coinciding with its edge [1] to being centred between two perforations [3], position that would finally be adopted as a standard.

It would also be around 1924 that agreements would finally be reached concerning the frame setting position, the position which would be set with the frameline between frames situated on the axis on the space between two perforations. This agreement, made for the silent frame setting has been kept for all other formats. .



F. 80
Surimposing of the films in the head of duplicating of a continous feed printer.

The last major decision concerning 35mm film perforation and cutting dimensions was accepted on an industry-wide basis solely in the late 1950's, when the new triacetate supports, of much better dimensional stability, and the development of the fast printers, made the acceptance of a different pitch for each of these two films inevitable.

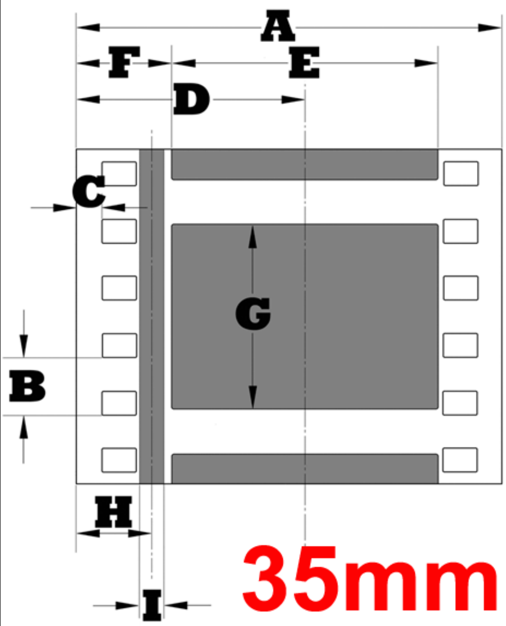
In fast printers, a sprocket feeds both the original film (positioned on the sprocket) and the raw stock both at the same time, although a film may be solely around 140 microns in thickness, this thickness is enough for the raw stock (located on top) to position itself with a bending radius greater than that of the original, and this difference would result in minor mismatches and slipping if both films were to be of the same size as regards their pitch. In the step printers which set the claws on the perforations before starting the movement of each frame, differences in pitch are not necessary.

Use of the short-pitch and long-pitch perforations has spread to all professional films. The short pitch is used for negatives and duplicates, and the long pitch for films for copies.

In 35mm, the pitch is 4.75mm for long-pitch films with a positive perforation and 4.74mm for short-pitch films.[96]

96 On special order, the manufacturers supply their films with any type of perfoation and pitch.

35mm film gauges. (According to norms ISO: 70, 491, 2906, 2907, 2939) Measurements in milimeters.



A – Rated width 35mm (Standardized 35.975 ± 0.025)		
B - Pitch	4.75 (long)	4.74 (short)
C – Distance from the perforation to the edge	2.01	-
D – Distance between the edge and the axis of the image	18.75	-
E – Width of the frame area	(camera)	(projector)
Silent	24.00 (theoretical)	23.00
Flat gauges	21.95 (minimum)	21.11
Anamorphosis gauge	21.95 (minimum)	21.29
F – From the frame area to the edge of reference	7.80 (maximum in camera)	
G – Height of the frame area	(camera)	(projector)
Silent 1:1'33	18.00	17.25
Normal 1:1'37	16.00	15.29
Wide screen 1:1'66	-	12.62
1:1'75	-	11.96
1:1'85	-	11.33
Anamorphosis 1:2'35	18.60	18.21
H – Between the edge and the axis of the sound column	6.17	-
I – Width of the sound column	1.93 (area)	2.54 (density)

3.212 - A Multipurpose Pitch: 16mm Films

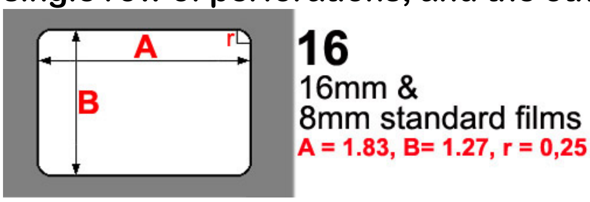
In 1923, using non-flammable supports, Kodak presented this type of film intended in principle, for amateur uses with reversal emulsions. Due to its image quality and the light weight of the equipment, 16mm film would soon be become the choice for many different professional uses, and in the 1950's and 1960's, it would play a fundamental role in the filming of television newscasts.

Film manufacturers market a large part of their negative, duplication and copy emulsions in 16mm, and there are emulsions (especially reversal colour emulsions) which are mainly or exclusively manufactured for this film gauge.

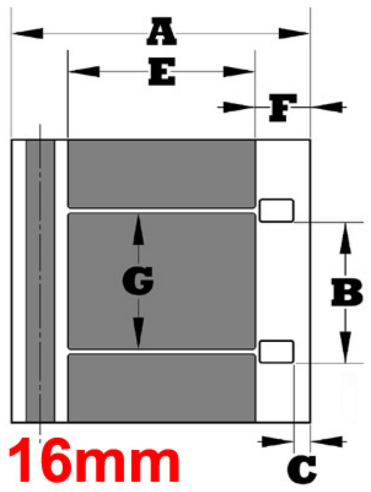
It was16mm that was used as the main support for the launching of the first reversal colour emulsions.

As would be the case for all film gauges except for 35mm film, the manufacturer/proprietor of the gauge set the fundamental dimensions which, following the success of the product, were accepted by the other manufacturers.

Initially, 16mm film was manufactured with two rows of perforations. With the advent of sound, single-perf film would then also be manufactured, having one single row of perforations, and the other edge being set aside as the sound area.



The perforations are rectangular, with the corners rounded and measuring 1.83mm by 1.27mm. The pitch is 7.620mm (long pitch) and on negatives and duplication stock it is 7.605 (short pitch).

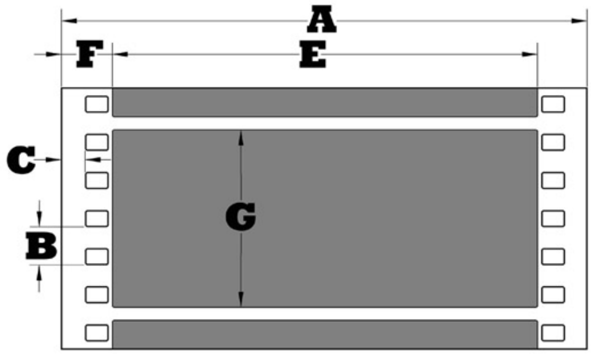


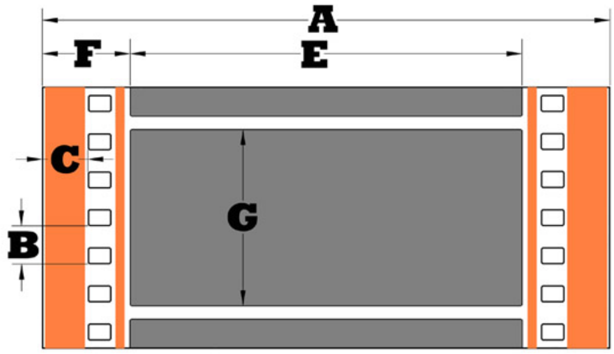
The frame height is bordered by a perforation pitch, each foot of film spanning 40 frames.

16mm film gauges (According to norms ISO: 69, 71, 359, 466) Measurements in milimeters		
A. Rated width 16mm	(Standardized 15.95 ± 0.025)	
B. Pitch	7.620 (largo)	7.605 (corto)
C. Distance from the perforation to the edge	0.90	
D. Distance between the edge and the axis of the image	7.98	
E. Width of the frame area	10.05 (camera)	9.65 (projector)
F. From the frame area to the edge	2.95 (maximum in camera)	
G. Height of the frame area	7.42 (camera)	7.26 (projector)
H. Between the edge and the axis of the sound column	14.48	
I. Width of the sound column	1.52 (area)	2.03 (density)

3.213 - Big Screens: 65mm / 70mm Films

The use of wide-gauge films was based on the prospect of achieving better screen image quality and on the need of adopting more oblong formats suitable for large movie theatre showing purposes.





65 y 70mm films gauges (According to norms ISO: 2404, 2467 y 3023) All the measurements are in milimeters		
A. Rated width 65 / 70mm	64.075 ± 0.025 (65mm)	69.975 ± 0.025 (70mm)
B. Paso de perforación	4.75 (paso largo)	4.74 (paso corto)
C. Distance from the perforation to the edge	2.97 (65mm)	5.46 (70mm)
E. Width of the frame area	52.50 (65mm)	48.59 (70mm)
F. From the frame area to the edge	6.24 (maximum distance in 65mm cameras)	
G. Height of the frame area	23.00 (65mm)	22.10 (70mm)

Almost from the start, the motion picture business has used films larger than 35mm in gauge. In 1896, Georges Demeny, in collaboration with Leon Gaumont, presented his Bioscope which used 60mm film with four perforations per frame. That same year, W.K. Laurie Dickson (one of the creators of perforated 35mm film), working in collaboration with H. Casler, would present his American Biograph, with unperforated 70mm films (which were feed using friction rollers). In the 1930's, other systems were patented which also met with little success, such as the Grandeur, a 70mm film with four perforations on each side and a width-to-height ratio of 1:2.13.

For spectacular movie viewing, many different 35mm films have also been used, filmed and shown simultaneously on one or more screens[97]. Cinerama, which used three films (plus a fourth film for sound), was the most successful of these systems.

In 1955, the Todd-Ao system brought out 70mm film once again, using supports with positive KS perforations, each frame having five perforations on each side.

On 70mm film, the negative film which does not need the large edge strips on which the magnetic tracks of the copies are added, measures only 65mm.[98]

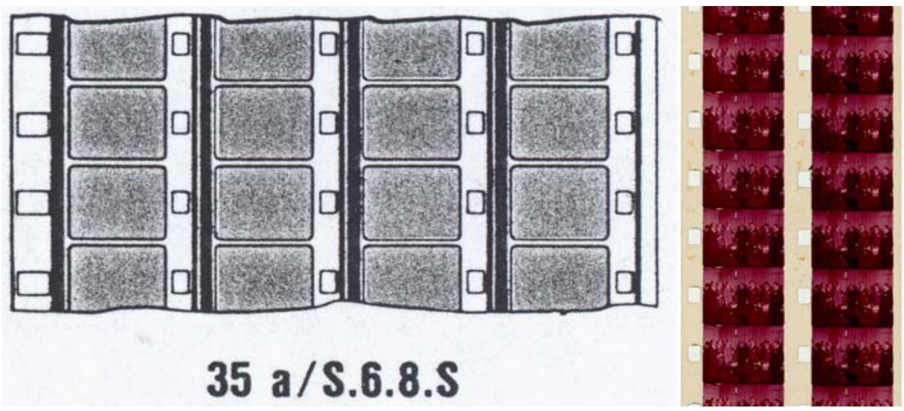
The 70mm copies have no optical sound track, but rather six magnetic sound stripes running along the edges of the film.

The Todd-Ao 65/70mm gauge film was accepted by the industry, which, with variations in the use of images with or without anamorphic compression (SuperPanavision, MGM), employed the same basic dimensions for positives and negatives.

3.214 - Films for family and non-professional uses

Just as is the case currently with regard to the home video system, there were two very distinct markets for films of these types, that is, the sale of raw camera stock and of equipment necessary for filming, editing and screening, and the sale (or rental) of copies of professional or education films filmed on professional supports and reproduced by reduction.

Most camera films are reversal emulsions, and these same emulsions are used for the direct copying of the originals. The negative emulsions are have used very little in cameras, and the mass reproduction for sale has been from multiple dupes made on 35mm or 16mm films.



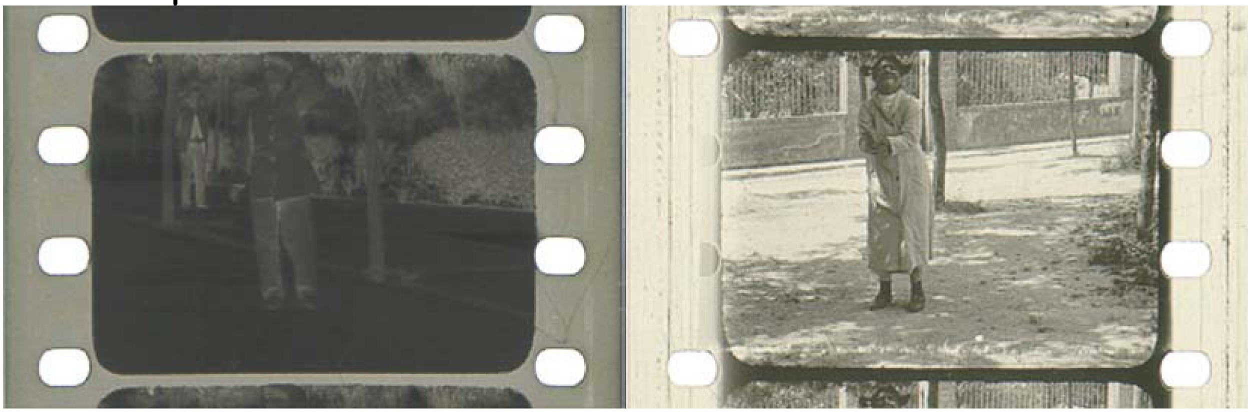
F. 86
Diagram of perfored 35mm film for the simultaneous making of four Super 8mm prints with magnetic tranck (Image from the catalogue: Agfa-Gevaert. Motion Picture Products, 1984). Multiple Super 8mm print in special support Eastmancolor 16mm.

97 Numerous systems have existed which would cover the 360° degrees of the circumference. The first of these systems was the Cinerama, mounted with ten projectors at the 1896 Universal Exhibition in Paris. Almost all of these systems have been very short-lived and have generally be confined to the event for which they were erected.

98 70mm negatives have been used in Eastern European filmmaking.

3.214.1 - 28mm

Pathé first presented 28mm films in 1912[99].



These films have the unique feature of having different perforation schemes on the negative and copy films. This film had two rows of perforations, the frame being bordered by three pitches on each side, while the negative had three perforations on each side. On the positives, one of the rows had only one perforations, which corresponded to the start of the setting of each frame[100].

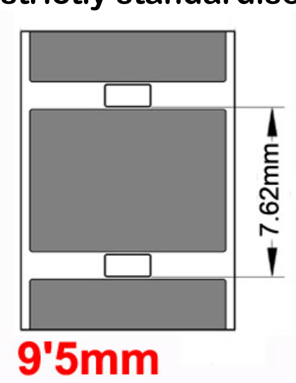
The image area measured approximately 14mm x 19mm, for a 1:1.6 aspect ratio on the screen.

Pathé also presented a 17.5mm film, the Pathé Rural, which was used for selling copies and had one square perforation per frame and 32 frames per foot of film.

F. 88. Pathé Rural. (Image obtained from: Eric Loné: "La fabricación de película en Francia antes de 1929". En "Archivos de la Filmoteca". F.G.V. Valencia, 1999)

3.214.2 - 9.5mm

Since their launching in 1922, the 9.5mm films (also known as Pathé Baby) were tremendously successful, but, despite their success, they were never very strictly standardised.



This film strangely coincided regarding a number of aspects with the 16mm film which came out some months later, that is to say, that it had one perforation per frame and 40 frames per foot of film, for a 7.62mm pitch.

The row of perforations was located in between frames, running along the lengthwise axis of the film. The perforation varied greatly in shape and size. The perforation was around one millimetre high and could vary in length within the 2mm-3mm range.

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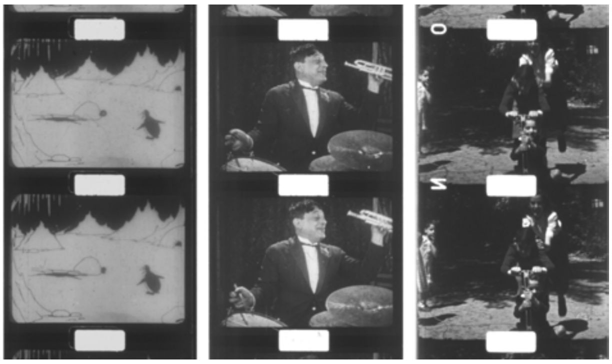
99 Under the "Pathé KOK" and "Pathéscope" trademarks.

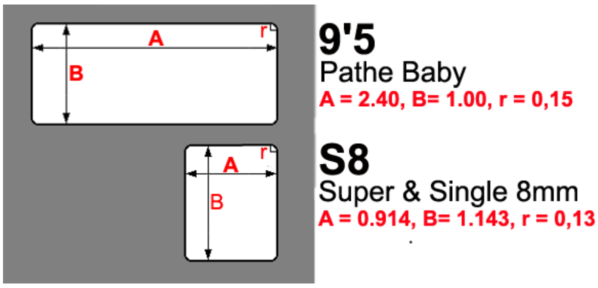
100 In United States, the 28mm prints were also released with three perforations on each side.



The camera and projector gates also varied in size (even in the most highly complex equipment built in the 1940's and 1950's). On many films, the frameline between frames was limited to a single line, broken by the perforation, and the edges of the perforation showed up on the screen when the film was shown.

The centred placement of the perforations poses a serious problem for conservation-related purposes[101]. Any break in the feed will have a direct bearing on the centre area of the image and, on the other hand, when the film contracts, the discontinuity which the perforations cause in the stock make the frames buckle separately, causing warping (bulging) of the frame which can be dangerous when the films are reproduced. .

To cut down on footage, a system of copies and projectors was introduced, by means of which, on coming to a title, a notch makes the feed mechanism "slide" over several frames, making it possible for the titles to be read despite being only two or three frames in length. This system (highly effective for its purposes) leads to the copies having large jagged areas which weaken them and contribute remarkably to their warping.



F. 92
Standardized perforations for 9.5 and Super 8mm

3.214.3 - 8 and S8mm

The launching of the 8mm films is directly linked to the success of 16mm film, which was already being used for scientific, educational, military jobs, etc.

Kodak used 16mm film, doubling the number of perforations, to market a cheaper system for amateurs.

This film was launched as Double 8 (its name having later been changed to "Standard 8") on supports 16mm in width which had to be threaded through the camera at both ends, one after the other, and after developing, were cut lengthwise into two 8mm strips which were spliced together lengthwise.

The perforations of the same type as for 16mm film, and one single pitch (3.81 mm) was used.

The image is framed between the axes of two consecutive perforations, 80 frames running along each foot of film. The row of perforations takes up a

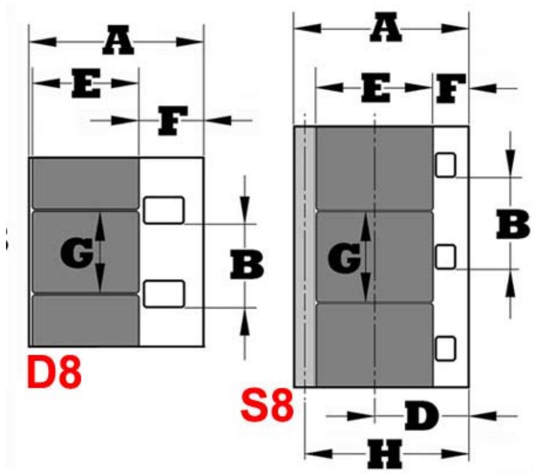
101 This centred-alignment of the perforations was adopted by other manufacturers as, for example, for the Ernemann Werke 17,5mm films.

considerable part of the available surface area, cutting down the image area by up to 3.6mm x 4.9mm (when screened: 3.4mm x 4.55mm), these being dimensions which mean format ratios of 1:1.33 on the screen.

The sound was added on magnetic tracks adhered after the film had been developed and cut. Double 8 films would be a tremendous success, which would solely be lessened as a result of the S8 gauges coming out in the 1960's.

The main novelty of the Super 8 and Single 8 films consisted of the introduction of cassettes/loaders which simplified their handling. After developing, the films are placed on standard reels suitable for screening.

Loader cassettes had already been used in 16mm films, but it was the S8 cassettes which came to be used on a widespread basis.



Doble 8 and Super 8 films gauges
(Norms ISO: 1700, 3027, 3625)

	8mm	S8mm
A – Standardized rated width	8 7.975 ± 0.05	8 7.975 ± 0.04
B - Pitch	3.810	4.234
C - Distance from the perforation to the edge	0.90	0.51
E - Width of the frame area	4.90 (camera) 4.55 (projector)	5.69 (camera) 5.46 (projector)
F - From the frame area to the edge	2.87 (maximum in camera)	1.47 (maximum in camera)
G - Height of the frame area	3.60 (camera) 3.40 (projector)	4.22 (camera) 4.01 (projector)

(*)The 8mm perforation is equal to the 16mm perforation.
The S8mm perforation is 1.143 high, 0.914 wide and a ratio of 0.13. All the measurements are in milimeters.

The characteristics and dimensions of the films of both of these systems are exactly the same. The perforations (0.914mm x 1.143mm) are rectangular, and their longest sides run lengthwise along the film. The only pitch used is 4.234mm, 72 frames running along each foot of film.

The filmed image area is 4.2mm x 5.69mm (the screened area is 4.01mm x 5.46mm) and is nearly 30% larger than that of Standard 8 film. The frame is set centred on the perforation axis.

Reversal camera films are marketed with or without magnetic tracks for live sound recording and, although not widely disseminated, for copy distribution, an optical sound track can be used.

The quality features which were achieved for S8 films are really remarkable. Despite these features, the launching of home video formats meant (although they still continue to be manufactured) that they would practically vanish from the market.

F. 95 - Super 8mm
Print with magnetic soundtrack to domestic release of “King-Kong”.

3.22 - Image & Sound Areas and Screening Formats [102]

The "image area" and "screening format" concepts tend to be confused with one another, and the term "format" is used to refer to both the area of the emulsioned surface which the filmed image occupies (image area) as well as the dimensions and proportions of the image on the screen (projection format)[103].

F. 96
Diagram of the security area in gauge 1 : 1,37 (according to norms ISO)
Area of filmed image: 21’95/16’00.
Area of projected image: 21’11/15’29.

The dimensions of the filmed image on the film are always slightly larger than those of the image actually seen on the screen.[104] Ultimately, the actual ratio between the filmed image area on the negative, that which is reproduced on the copies and the format seen on the screen depends upon the systems used for making the copies and, above all, on the clipping done by the gate aperture on the projector.

Apart from this, the image area in negative and positive is used very differently in numerous panoramic systems, and to reproduce the copies or to properly screen the film, lenses which change the dimensions of the image must be inserted.

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102 See TEXTUAL NOTE IX concerning photochemical film formats.

103 In the FIAF multilingual publication Terms and Methods for Technical Archiving of Audiovisual Materials / Terminología y métodos para archivo de materiales audiovisuales (compiled by Günter Schulz and Hans Kamstädt and edited by K. G. Saur, München-London-New York-Paris, 1992) while the terms “width” and “largeur” meaning “ancho” in Spanish are used in English and French, the terms “format” and “paso” are used in German and Spanish.

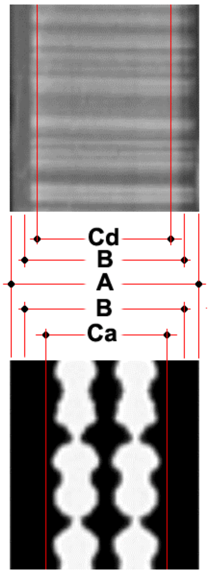
104 This difference is employed to provide a "safety zone" to prevent the edge of the photographed image from showing up on the screen. Even with the finest equipment and completely new films, it is impossible to prevent there from being minimal differences in the positioning of the film in cameras, copiers and projectors. When showing the film, these minor differences would be perfectly noticeable if the edges of the image were to be seen on the screen.

When considering the dimensions of the sound area (its width), a distinction must be made among three different concepts:

[A] - The space set aside for the sound of the frame surface, which runs from the edge of the perforations (35mm) or from the edge of the film proper (16mm) up to the image area, and which is known as the "sound reserve" or "sound area".

[B] - The sound track which may be of different lengths depending upon whether it is of the variable or dense-area type.

[Ca - Cd] -The area actually scanned by the sound readers and played in the theatres which, in order to allow for correct reading despite the inevitable differences existing among different projection equipment, is slightly narrower than the sound column.



The magnetic sound systems have their own sound areas well-marked on the film.

In recent years, as a result of the digital optical sound systems coming out, it has become necessary to allow there to be several sound areas on the same film.

3.221 - Image Areas (Camera Aperture) and 35mm Projection Formats

Due to the lack of standardisation and to the quasi-handmade characteristics of filmmaking equipment manufacture during the silent film era and, later, due to the filmed image area not being a fundamental element for the filmmaking business for sound films, the fact that the image filmed on a negative and reproduced on the copies is not exactly the same (or even not the same at all) as that which is shown on the screen is a situation which is found to exist frequently.[105]

F. 98
[A] Positive duplicate of a film shot in Super 35, to obtain prints in Scope [B].

105 During the silent film era, the "projection format" concept can only be considered as being a technical element and, in any event, relatively unified for the leading moving picture shows. And the indifference regarding the dimensions of the filmed image area seen on the screen still currently continues to exist, although, the aspect ratio is obviously usually respected for building projector gates.
During the inspection of a batch of 30 films made at the Spanish Film Archive Recovery Department, a check was made of the filmed image area dimensions and proportions. The films were selected as a result of being filed in the same time period and academy or flat panoramic formats. Three of these films (panoramic) incorporated scenes filmed in academy format, and in one of them, only the header had been processed in panoramic format (1:1.66), while all of the rest of the image was in 1:1.37. In 29 films, the aspect ratio did not tally with the theoretical standard of their format, one film with a 1:1.55 format even having been found. Solely in one film (1: 1.37 format) did the theoretical and actual format tally.

3.221.1 - Silent Films

In silent films, each camera had its own gate dimensions, and the filmed image area could even penetrate very deeply into the perforation area. The frameline between frames might respect the theoretical millimetre space or might consist of a simple line along the edge between one frame and the next or even might not exist at all, and the top and bottom edges of consecutive frames could overlap.

The framing position could vary along the full length of the pitch. The frame might be aligned with the top or bottom edge of a perforation, might be centred between perforations or be located anywhere in between. It was not until 1924 that the standardisation of the setting on the axis between perforations started to be accepted.

Generally speaking, during the silent film era, the theoretical image area which was projected on the screen was 24mm in width by 18mm in height and was perfectly well-centred on the lengthwise axis of the film.

If the dimensions of the gates on the old silent film projectors are measured (making certain that they have not been revamped), how they vary from one projector to another becomes patent. Back almost at the end of the silent film era, dimensions of 17.25 mm /22mm were set, which maintained the proportions (aspect ratio) of 1:1.33, but this standardisation must have had very little impact.

3.221.2 - The Talkie Standard

The advent of talking pictures would change the whole situation. The placement of the sound area beside one of the rows of perforations inside a space set aside for the image made it necessary to shift it horizontally and to add a new concept to its definition, that is, the "distance to edge in question" (on 35mm film, the edge of the film nearest to the sound area) which would mark the location of the vertical axis of the image frame.

Although the sound systems spread out over the market have major differences as regards the width of the sound track, in general, it can be said that the sound area or sound reserve takes up approximately three millimetres of width on 35mm films. The theoretical 24mm in silent films changed to 22mm[106], and this new width led to an imbalance in the height-to-width ratio of the image (for 18mm /22mm, the ratio would be1.1.22).

Placing higher priority on maintaining the image proportions than on the most efficient use of the emulsion on the film, the Hollywood Academy implemented a further reduction of the image area, widening the space between consecutive frames (frameline between frames) and cutting the image down to 16.55mm in height by 22.05mm in width, these being dimensions which exactly tallied with the 1:1.33 ratio.

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106 The sound area also uses up most of the safety space which was formerly left between the image and perforations.

In practice, the "Movietone" format, measuring 16.03mm in height by 22.05mm in width, became the leading format, and the aspect ratio for talking pictures was then 1:1.37.

F. 100
Frame of the first spanish sound film. We can observe that the movie was filmed with a silent camera and the proportions of the area of image are 1:1’16.

The projector aperture gate dimensions were also made smaller, an aperture of 15.25mm / 20.96mm becoming the most popular, which maintained the format aspect ration of 1:1.37.[107]

Over the following twenty years, the "academy" format would take hold as one of the most valuable standards in the industry, up to the point of its currently being known as the "regular or standard format".

3.221.3 - Panoramic Image Systems

Filmmaking being part of the show business industry led to systems being developed which would allow the use of larger-sized screens, simulating the enveloping panoramic nature of real images for the image on the movie screen.

The panoramic image provided a highly important added advantage on enabling the installation of large-scale screens in wider theatres lower in height than those required for "conventional" screens of similar dimensions.

For the systems based one single 35mm film, two different techniques were developed. The first and most important of these techniques employs lens systems to modify the geometric aspects of the images by compressing them on filming and then expanding them again during reproduction. The second, much more economic technique, which has become tremendously widespread in use, consists of not using a large part of the emulsion surface of the film, using standard spherical lenses but setting the image on a more or less elongated central rectangle.

3.221.31 - Anamorphic Compression Systems

The first new development that met with commercial success and was the driving force behind other similar systems coming out on the market was CinemaScope, in 1952.

The CinemaScope system was based on the filming and projection of the image using cylindrical lenses, such that the real image was photographed "anamorphised" with the horizontal dimension compressed by the optical conversion made by way of the lenses. When shown on the screen, these stylised images were "deanamorphised" by another cylindrical lens mounted outside of the projector's optical assembly.

107 The measurements are as per the standards backed by the American Standardization Association (ASA), the ISO standards differing slightly (16.00 / 21.95 for the image area and 15.29 / 21.11 for the projector) however respecting the same aspect ratio.

In the first "CinemaScope", which worked on four magnetic sound tracks on the copies, the image area dimensions were almost identical to those of the silent film format (18.67 / 23.80) and, like that format, was located centred exactly on the lengthwise axis of the film. The projector aperture was 18.16 / 23.16, for an aspect ratio of 1:1.27. The cylindrical lens doubled the width of the image, achieving an aspect ratio on the screen (projection format) of 1: 2.44.

The AC (Foxhole) perforation was created in order to be able to position the four magnetic tracks of that first CinemaScope. Three of these tracks were for the signal to three speakers located at the centre and to either side of the screen, the fourth track containing effects to create an "ambience" for the speakers located throughout the theatre.

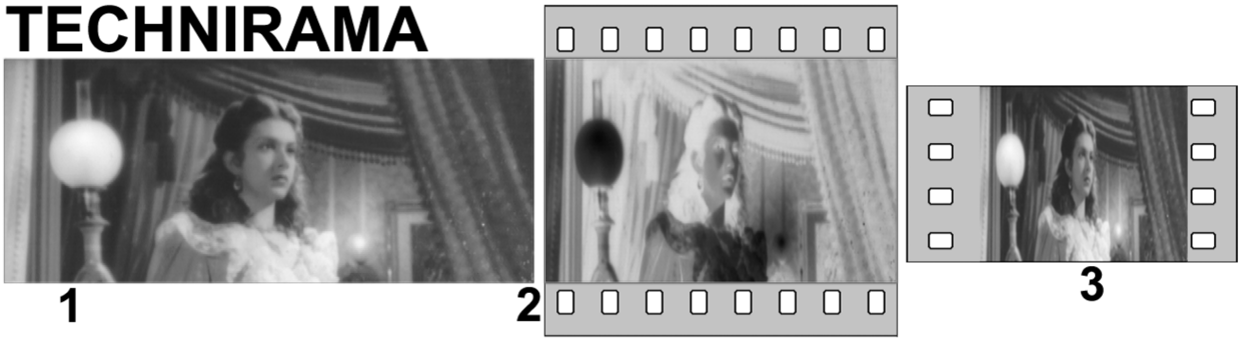
The first CinemaScope copies came up against the requirement of equipping projection rooms with projectors and, above all, with scanning and amplification equipment suitable for handling four magnetic tracks. To remedy this serious commercial problem, CinemaScope brought out two variations on its system, the first of which continued to have the four magnetic tracks and the AC perforation, but also added a conventional optical track; the second doing away with the magnetic sound and returning to the use of the standard perforation.

F. 101. [1] Diagram of Cinemascope 4 tracks with perforation Fox. [2] Diagram of standard Cinemascope.

Bringing back the use of optical sound made it necessary to reduce the image area to 18.67 / 22.10 and the projector aperture (18.16 / 21.31). The proportions of the projected image were therefore 1:2.35.
The success of CinemaScope led to the other systems which have used anamorphic compression to having adopted the x2 multiplication as the image decompression factor.

Other "scope" systems used different schemes for negative filming and copy stamping. The most well-known of these systems were Technirama and Techniscope.

Technirama (perhaps the highest-quality of any the anamorphic image systems) was used in a rather large number of productions starting as of the mid 1950's. The negative was filmed on 35mm film running horizontally through the camera, creating frames taking up eight perforations. In this system, the image was compressed twice horizontally, first on the negative and then on the printing of the copies, thus achieving the same overall anamorphic ratio as CinemaScope (x2) and therefore being able to use the same projection equipment. Despite the tremendous photographic quality achieved, it came up against the need of using up twice the amount of negative film for shooting purposes.



F. 102 - Diagram Technirama
[1] Filmed image (47.48/23.80) [2] Technirama camera negative with 1'5 of lateral compression (31.654/23.80) [3] Positive reproduced with lateral compression of 1'33 and 22.55% reduction to frame in the Scope standard (23.80/18.67mm).

New colour emulsions (more sensitive and less grain) having come out on the market made it possible for systems like Techniscope (generally known as bi-standard or "two-pi" systems) to be created in the 1960's, in which each frame would take up two perforations.

In Techniscope, the negative was filmed with cameras using spherical lenses, but with the feeder systems modified to achieve frames measuring solely two perforations in height. The anamorphic lenses were employed for making copies, to vertically enlarge the frame up to achieving the dimensions of the image area filmed in CinemaScope. On projection, the image was re-enlarged (this time horizontally), achieving the proportions of the rest of the "scope" systems (1:2.35). The projection image quality was low, but this system involved major monetary savings as regarded the shooting process.

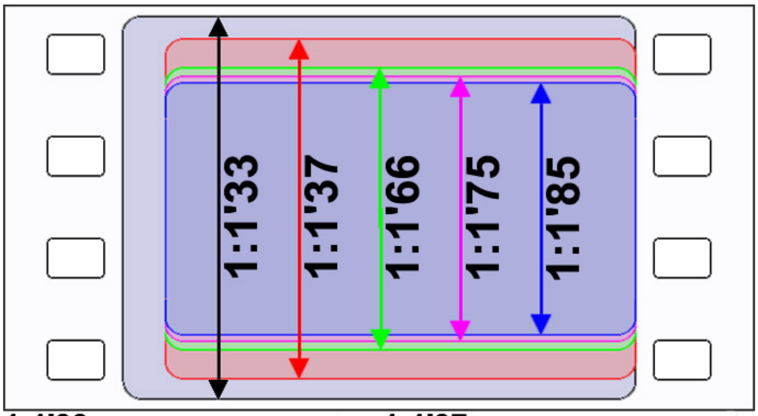
The conservation of the motion pictures filmed with the original CinemaScope centred image area or with Technirama's or Techniscope's eight or two perforations (or in flat-image Vistavision, requires the conservation or rebuilding of the equipment necessary for the duplication or copying of these negatives.

3.221.32 - Flat Panoramic Systems

Although attempts had been made from the very early years of talking pictures to make the screen image wider using conventional spherical lenses, it was CinemaScope's success which would be the driving force behind the launching of flat panoramic systems, in which the filmed image retains its "natural" proportions on the film.

Vistavision may be the finest-quality system created on 35mm films. The film was run horizontally through cameras and projectors, with frames running lengthwise taking up eight perforations and the copies being of exactly the same dimensions as the negative. The degree of quality achieved is truly spectacular, but the cost of the negative and the need for the theatres to adapt their projection booths to take the large horizontal reels of the copies prevented Vistavision from achieving all of the success it deserved based on its quality.

This system would never been fully standardised and, depending upon the equipment used, the aspect ratio of the image on the screen fell within the 1: 175 - 1: 1.85 range.



1:1'33 (18.00/24.00 = 432mm²) **1:1'37** (16.03/22.05 = 353.4mm²)
1:1'66 (13.27/22.05 = 292.7mm²) **1:1'75** (12.58/22.05 = 277.3mm²)
1:1'85 (11.91/22.05 = 262.8mm²)

F. 103. Area of emulsion used in the 35mm gauges.
The gauges of silent (1:1'33) are conventional. The height of the filmed image in the wide screen gauges is not standardized.

Reasons of a commercial and aesthetic nature led to oblong projection formats (imitating scope formats) to be launched, in which a large part of the emulsioned surface of the film was used.

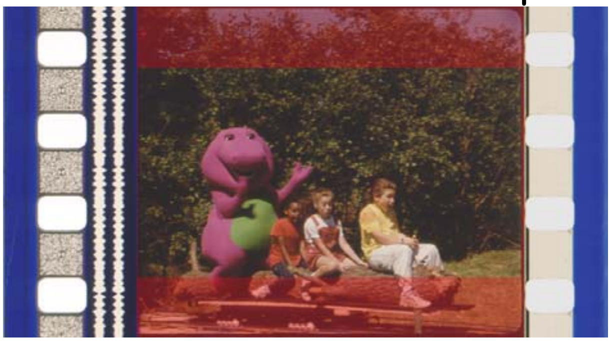
Despite the lower quality involved in not using the film to the maximum, these formats have met with tremendous success. Three of these formats, corresponding to the 1:1.66, 1:1.75 and 1:1.85 aspect ratios, have gained quite widespread use under different names.

Currently, most of the films which are shot on flat formats are set for 1:1.66 or 1:1.85 aspect ratios, regardless of the camera gate dimensions.

The many different types of both anamorphic and panoramic formats, in addition to the possibility of filming in 35 "scope" for making 70mm copies has led to a "wide open" gate (sometimes known as "Super 35") being mounted on many cameras, this gate being similar in size to that which was formerly used in silent films or the first CinemaScope.

Figura 104
[1] Negative Duplicate of a film shot in Super 35 Scope for standard Scope. [2] Scope copy. [3] (marked in green) Numeration introduced by the editor of the negative on the part of the image corresponding to the sound track.

When archives receive motion pictures filmed using this type of camera but set for flat panoramic formats, it may be totally impossible to determine what format must be used for showing them on the screen without availing of information from the studio where the film in question was produced



F. 105
Image filmed in Super 35 camera format, for projection with a wide screen format 1:1'85.

The first Cinerama worked on three 35mm films (plus a fourth one for the magnetic sound tracks), the frames running along the length of six perforations. The screen being curved and the overlapping of the contact bands among the three images make it impossible to set any fixed criteria concerning its aspect ratio. If the width of the three flat images were to be considered, aspect ratios would be 1:2.71, but the curvature lessens the perception of these proportions to approximately 1:2.20.

3.222 - 16 mm Image Areas and Projection Formats

16mm as well as 9.5mm and 8mm films can be considered as being single format films.

For this gauge, the image area (7.49 /10.26) is four and a half times smaller than the 35mm image area. The aspect ratio is exactly the same as the silent film aspect ratio of 1: 1.33.

Despite a low diffusion, panoramic formats can be found in 16mm formats, on copies of motion pictures filmed in 35mm.

The Super 16mm format (type W 16mm) is a camera format which is used for making 35mm copies with a flat panoramic format.

According to ISO standards, the camera image area dimensions must be 7.42 / 12.53, for an aspect ratio of 1:1.68. The image area runs into the area set aside for the second row of perforations, that is, the area for the sound track on copies - preventing it from being used directly for making sound copies.

F. 106 - Super 16
Camera negative, postive print obtained to study the amplification and negative duplicate amplified to 1:1'66 (Samples given by Iskra, S.L.)

This format was developed to a certain degree due to its prospects of being used for high-definition TV system, as its screen six (16/9) is approximately the same. For use on television, it can be synchronised with separate magnetic sound. This format is currently used solely for TV productions and low-budget motion pictures, in which the use of 16mm negatives can mean major savings on stock during the shooting process.

3.223 - 70mm

The ample width of 70mm films affords the possibility of screening in flat panoramic formats on big screen providing a very high-quality image.

In systems such as the Todd-AO and the Super-Panavision systems, the frame takes up five perforations and, in keeping with the ISO standards, the projector gate dimensions are 22.10mm / 48.59mm, for an aspect ration of 1:2.20.

In many productions, the 70mm supports have been used solely for making deanamorphised copies of motions pictures filmed in 35mm "scope" and also for making 35mm anamorphic copies of motion pictures filmed in 70mm.

F.107. 70mm IMAX(Image: Fotofilm Madrid)

Numerous special formats for spectacular showings are used on this type of film. The most well known are the Omnimax (for spherical screens) and the Imax (for cylindrical screens. In these two cases, the frame runs horizontally along 15 perforations.

Nevertheless, it cannot be said that there are any standardised for this type of spectacular formats. The lenses necessary for anamorphically converting the image depending upon the shape-related needs of the screen on which each copy is going to be shown are often inserted during the shooting process and for making copies.

3.224 - 3D Formats

Many systems have been developed for stereoscopic filming on 35mm and 70mm supports.

From the photographic standpoint, these systems can be classified into anaglyphic and polarisation systems.

The anaglyphic systems film the images related to the two complementary colour lights (normally cyan and magenta) separately and must be viewed through filters of these same values, mounted on glasses. If the magenta filter is used for filming the images which will be viewed through the glasses by the right eye, the cyan filter will be placed over the right eye, so that only the magenta image can be seen. In principle, this system solely affords the possibility of filming B/W images, but it has also been used in subtractive two-colour separation system for colour and 3D motion pictures.

The polarised light system works on a similar scheme, by inserting two polarising filters placed in a " \ / " arrangement. These polarisation filters make it possible to use colour film.

Depending upon the system in question, either one or two 35mm negatives are used. In the single-negative systems, each frame may take up four perforations (which means eight perforations by double image) or may use a double gate two perforations in height per frame.


Figura 109
Systems of polarized light: two perforations 35mm picture negative and standard 70mm print of broken frame.

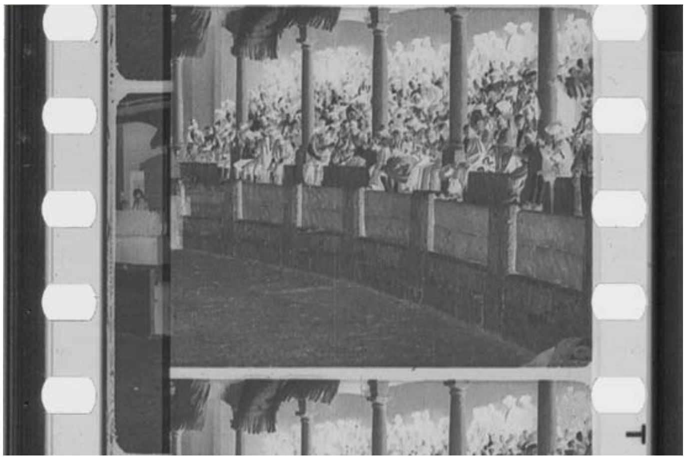
3.23 - Gauge and Format Compatibility

The professional film marketing-related needs throughout all areas involved in movie business distribution have led to blow-down and/or blow-up systems having been created for making reproductions on gauges or formats differing from the original.

When making a reproduction of a film of a different gauge, the photographic characteristics of the image will inevitably change. The photographic resolution which can be achieved on a film is determined, first of all, by the resolution characteristics permitted by the emulsion, but it is also determined by the emulsioned surface available for each film gauge.

In "Textual Note X" in the end notes, a Table is provided indicating the ratios between the areas available for images on professional supports. As is shown in said Table, the surface area available on 35mm film is almost three times less than that which is available on 70mm film, that which is available on 16mm film being more than 4.5 times less than on 35mm film.

For reductions, the image resolution will be lessened similarly to that of the area of the frame, which will make it necessary to reduce the size of the images shown on the screen. For enlargement-based reproductions, although the actual resolution of the image will be that of the original, by properly combining the density and contrast values with the increase in the available image area, a certain increase can be achieved in the subjective perception of the image quality.



F. 110
Negative duplicate of a silent print, obtained in a sound contact printer in the fifties.

Overall, accepting the changes in the image qualities and in their projection-related possibilities, all gauge changes can be made satisfactorily. From this standpoint, all film systems are compatible.

Changes in format involve another type of compatibility-related problems. The proportions of the image in each format are absolutely unchangeable, and even changes as minor as that involved in reproducing a silent film format on a sound format (1:1.33→1:1.37) would mean an image loss.

When the dimensions of the 70mm format were first being considered, they were thought of as being the same as those of the 35mm "scope" film, so that there would be no loss whatsoever, but the industry has made all sorts of changes in gauge and format, often without taking the image which was going to be lost into account.

A reproduction from a silent format to a sound format made by reduction and correctly setting the frame would involve a loss of only 0.5% of the image; but, when incorrectly done, by contact, as has often been the case, it would involve a loss of 19% of the image and would leave the frame axis off kilter.

Figura 111
Change in gauges from the silent to the sound film
[1] Original frame
[2] Reduction well framed without loss of image.
[3] Diagram of direct duplication with loss of image in the reserva de sonido and in the frame lines.

There is no way whatsoever of correctly making changes from "scope" formats to flat panoramic forms in 35mm. If the reduction is done respecting the flat format dimensions (i.e. 1.85), there would be more than a 25% loss of image; and if it were to be attempted to conserve the entire deanamorphised "scope" image, the height of the photographed image on the resulting frame would be less than 5mm.

Figura 112
Change from Scope to Widescreen
Frames of a film shot in scope and of a trayler made by simulating the proportions Scope and be projected with wide screen lenses 1:1'85.

Transferring formats is an especially major problem when the telecine processing of motion pictures filmed in panoramic formats into video format is involved.

The proportions of the conventional TV screens (4/3) are exactly the same as the silent film aspect ratio (1:1.33) and quite near the sound standard (1:1.37).

Telecine processing has been done based on two criteria.

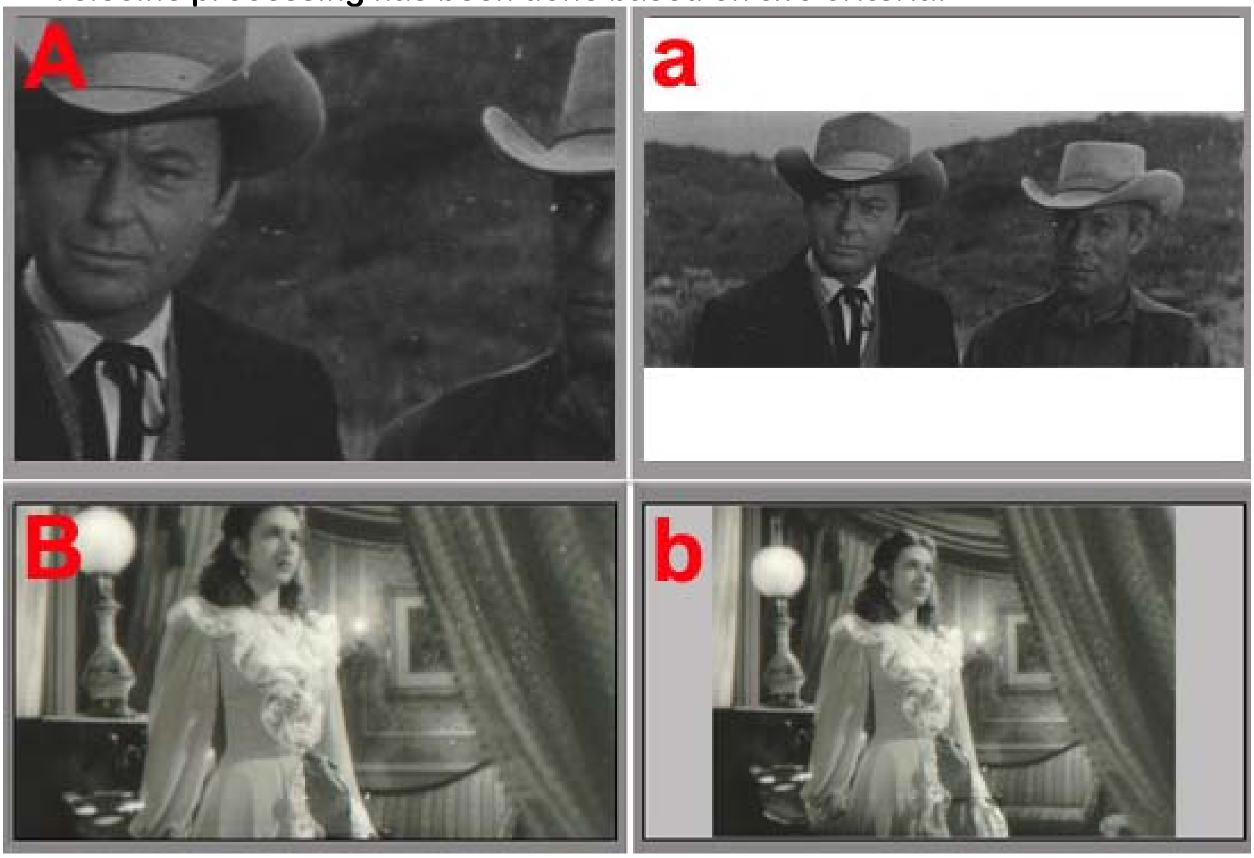


Figura 113 - Formats adapted for TV
Adaptations of Scope to screen 4/3 and of format 1:1'37 to screen 16/9
[A-B] Using all the surface of the screen, [a-b] leaving two empty bands.

First, the fact of using the entire TV set screen entails from a 44% loss of image (if the original is in "scope" format) and a 20% loss of the image of the originals with format 1:1.66. The degree of these losses has led, for some "especially tricky" motion pictures to being telecine processed using special techniques by changing the editing (dividing the frame into different areas and editing images from these areas, in a mock "shot/countershot") or by making false pans to go from one side to the other of the image area.

The second system consists of not using the full height of the screen, creating a false elongated "image area". In this system, based on the use of 1:1.66 formats solely 80% of the screen would be used, and solely 55% of the screen for the "scope" formats. And reducing the surface area of the screen used means reducing the number of lines of information available for forming each image. In practice, telecine processing is usually done by disregarding the image areas located at the ends of the panoramic frame and using 80%-70% of the surface area of the screen and of the lines available for forming the image.

On 16/9 format screens, this problem has been lessened considerably, such that in order to reproduce a "scope" image in full it would ONLY be necessary to waste 25% of the TV screen.

3.3 - Film Sound Systems and Formats [108]

Due to their sound and listening characteristic proper, the systems created for filmmaking sound recording and reproduction purposes must be totally different from those used for moving images.

Motion - the shift in position which must take place over time - is a characteristic which may or may not exist in all that which we perceive in image form. To the contrary, as far as sound mechanics is concerned, development over the course of time is a substantial characteristic, and any interruption or change in that development over time will alter the characteristics of the sound in question.

Moving image reproduction systems must be based on still images, and the sense of movement (if the object viewed is moving) is achieved by means of the identification of the differences between consecutive images, by way of what could be described as being a reconstruction of fade-ins or fade-outs / dissolves.

For sound, there is always development over time and, in order to pick up all of the vibrations comprising each sound element (vibrations which may have started and may end at different points in time), sound systems must keep running continuously (in constant motion) until the last vibration of the last of the frequencies comprising the sound "moment" has ceased.

What images and sounds can be reproduced with the same synchronisation with which they actually occur is the number one requirement of sound filming.

As a result of this requirement and due to the characteristics of sound and image which have been discussed at an earlier point in this document, in all filmmaking industry sound systems, the moving images and the sound must be recorded and reproduced by means of different devices at constant rates of speed.

As long as solely images are involved, filming and screening can be done at different rates of speed. As the past history of silent film screenings during the sound era goes to show, the figures may move faster (or slower), but both the figures as well as their movements are perfectly well identifiable on the part of the viewers.

If a motion picture filmed at 16 images/second is screened at a rate of 24 images/second (meaning speeding up the movement by 50%), the viewers will see the people walking across the screen very fast, but they will not confuse them with people running across the screen.

To the contrary, changes in speed totally change the characteristics of the sound reproduced. If, for example, the projection speed of a film is speeded by 33% (from 24 i/s to 30 i/s), the sound of a musical note "E" of 330 cycles would become a "A" of 440 cycles/second, and lesser but irregular variations would lead to "wows" which would garble any recording to the point of making it unintelligible.

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108 **See TEXTUAL NOTE IX concerning photochemical film formats.**

3.31 - The Evolution of the Functional Structure of Filmmaking Sound Recording Stock [109]

Making allowance for all sorts of exceptions and not basing ourselves on any time-related criteria, the stock employed for recording filmmaking sound can be divided into four different operating schemes:

The first of these operating schemes is that of the sound recordings of what is commonly referred to as the "silent film era", throughout the 1927-1931 period. In the "silent film era", filmmaking sound was not reproduced, but rather was created or played live right in the theatres while the film was being shown and was more or less synchronised with the showing of the films. Music was the most important sound element at this stage of sound, and the typical remaining records thereof - sheet music, music lists and synchronisation notes - are conserved on paper.

The other three schemes have to do with sound reproduction systems and have been developed, starting in 1895, throughout the entire history of filmmaking.

The synchronised reproduction of sounds and images would first begin on systems in which the recordings -- the phonograph cylinders or records and the films - were separate materials, and the synchronisation was done by means of mechanical devices.

In the third scheme of stock, the sound and image recordings were made on different media (media which may be for one same system or for different systems), but for reproduction, during the showing of the film, both elements were on one same medium. Lastly, in the fourth scheme of stock, the sound and image recording can be done on one same medium. Given that this scheme of stock developed in electronic filmmaking, it will be discussed in the sections dealing with these technologies.

3.311 - Sound in Silent Films

Filmmaking never wanted to be silent.

Throughout the first thirty years of filmmaking, the sound reproduction systems at that time did not afford the possibility of a truly efficient combination with the moving picture production system, but the film showings had sound accompaniment which, at least for full-length feature films, was prepared during the production of the motion picture proper and could be taken into account during the image editing process.

F. 114
Music sheet for the cinematographic adaptation of a spanish movie.

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109 The preparation of the sections devoted to sound during the silent film era is based on the research done by Lucino Berriatúa.
Regarding the initial beginnings of sound production, data obtained from Claude Lerouge "Sur 100 années, le Cinéma Sonore", Éditions Dujarric, Paris, 1996 has been used.

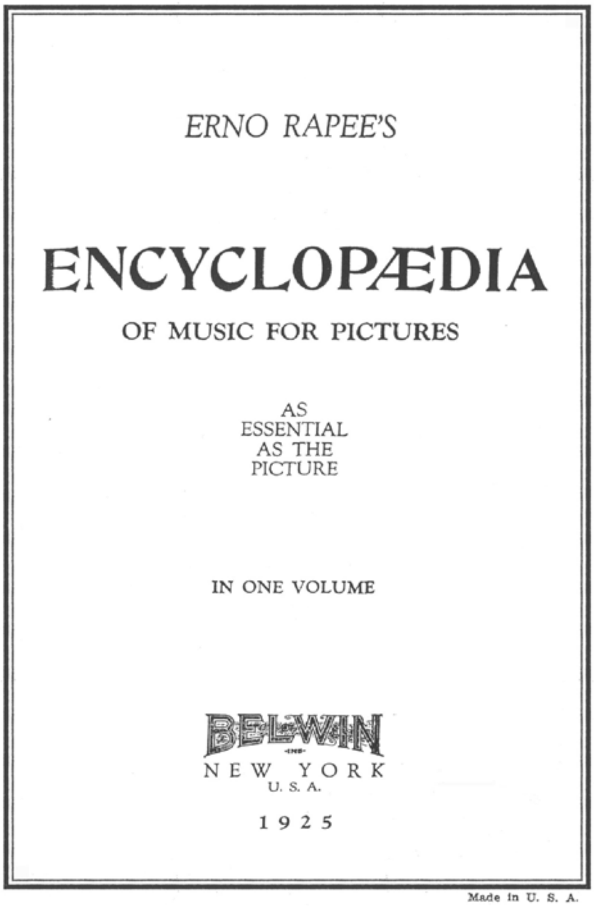
Nevertheless, on not being reproduced, silent film sound can be considered to be an accompaniment, that is, an accompaniment which may be absolutely essential to understanding some motion pictures correctly, but which could vary from one showing to another, depending on factors as unrelated to the sound per se as the financial standing of the theatre owner or how much of a box-office success the motion picture was at the time.

Sound accompaniments could include anything from a presenter-narrator-commentator or a single pianist, up to an orchestra with soloists and choruses singing a score composed expressly for the film. In practice, all of the music-hall or light opera sound resources were used for accompanying the showings, including creating sound effects and, in some countries, the live acting out of the voices by groups of actors.

Music was the most typical element of these motion pictures, and the only one which has left any tangible records of the sounds used.

Individual scores (scores including notations for their proper synchronisation with the pictures on the screen) were written for many films, and music lists were prepared for many others, these lists possibly including a selection of snatches from already-existing compositions or solely indicating the musical beats or "tempos" most suitable for each scene, along with notations as to when they should be played.

Apart from this, for those films for which no specific score had been written or for those theatres which (for one reason or another) had no original score, collections of music were published, organised by themes (love scenes, fight scenes, action, tension, etc.) that served as an aid to the musicians who had to improvise the musical accompaniment.



F. 115: Stock plays album for accompaniment of showings.

3.311.1 - Silent Film Sound Conservation

Silent film scores must be considered as being sound recordings made on paper, and their conservation is not independent of the "silent" films to which they pertain. "Silent" films cannot be fully understood if it is not in conjunction with their music (with their original sound), and their scores make no sense if they cannot be put together with the images for which they were composed.

But the conservation of silent film sound cannot be confined solely to the scores, music lists and collections of themes which were prepared for the accompaniment of the films. The sound of the silent films was not a reproduction and could differ each time the film was shown. One score would be played adapted for an orchestra or for a piano, or with spectacular accompaniments (i.e. the firing of cannons). Apart from this, in many cases, during production or distribution, different sound accompaniments might be prepared for one same film [110]. In order to understand and conserve "silent" film sound correctly, it is also necessary to recover, conserve and use the newspaper library, bibliographic and even biographical information which will make it possible to evaluate and use the sound recordings preserved.

3.312 – Mechanical / Electromechanical Sound and Image Reproduction

Starting in 1894, the year in which Edison began his trials for creating the Kinetophone, which would mechanically synchronise the Kinetoscope and phonograph, up to the Vitaphone system (used for The Jazz Singer in 1927), which electromechanically synchronised films and gramophone records, the history of the first thirty years of filmmaking is filled with attempts at achieving simultaneous, synchronised reproduction of the image and sound recording made on different media, that is, motion picture films and phonograph rolls or records.

The characteristics of the reproduction which could be achieved from those cylinders or discs, which would determine the failure or success of the systems to come and, in short, the possible triumph of the sound film business, depended upon three closely-linked problems being solved:

- The synchronisation between sound and images
- The capacity of the speakers to cover the volume of the theatres
- The articulation of the sound reproduction

The synchronised reproduction of the sound and image recordings was achieved by way of many different designs.

In Edison's Kinetophone, which was presented twice (1895 and 1913) and in the system exhibited by Léon Gaumont in 1900, synchronisation was achieved by means of mechanical connections between the two sets of equipment.

Later, Gaumont, Messter and others would introduce an electrical control for the phonograph record changer, which was controlled from the camera/projector feeder mechanism.

Full-scale synchronisation between the two sets of equipment would be achieved by equipping both with electric motors, connected by means of a third three phase selsyn motor. The Gaumont Chronephone and the Vitaphone projectors would run in perfection sync with this system.

Continuously-growing theatre capacities made the use of the original phonograph horns.

Numerous mechanical procedures were attempted for increasing amplifying power and some, such as the compressed air-based Elgephone system, would be somewhat successful, but it would be only by means of the use of the electronic "triode" valve, designed and developed by Lee de Forest c. 1906 that

110 These difference could be added during the preparation of the negatives to be used in different geographical areas. In the research done for restoring "Faust", Luciano Berriatúa has reconstructed two of the musical accompaniaments prepared for this motion picture, those for the second editing of the German negative and for the premiere showing of the American negative.

the amplification necessary to cover any increase in theatre size would be achieved.
By allowing the increase of the response of the microphones and of the record recording and reproduction equipment, the "triode" valve would also be able to pick-up the level of articulation necessary in recordings and reproductions.

3.312.1 - Conserving Sound as Reproduction

When posing the idea of the conservation of the first motion picture sound recordings, along with the specific problems related to the ageing and damaging of the media (cylinders and records) used in each system, a much broader-ranging problem which has a bearing on the quality and on the accessibility of those reproductions and which must also be dealt with in the conservation of the sounds from later eras must be approached.

Some of the characteristics of those sound recording, such as the amplitude of the frequencies recorded, which are relatively independent of damage which the recording may have sustained (which can therefore be detected and respected in modern reproductions and restorations), but many other characteristics such as the background noise or the amplitude and loudness of the reproduction, may be completely modified by damage or be impossible to determine if valid data regarding the characteristics of the equipment used for creating and reproducing these sound recordings are not still in existence.

In order to conserve filmmaking sound, a better knowledge must be gained as to the equipment - from the equipment used in recording up to the theatre amplifiers and speakers which were used in creating and showing films.

3.313 - Sound and Image Reproduction from One Same Medium. Sound As Image

Selsyn motors guaranteed flawless synchronisation between the image and sound systems[111], but the synchronisation was lost if the film broke or the record was scratched. These types of incidents can only be overcome if the image and sound recordings are on one same medium, and for the technologies existing throughout the first fifty years of filmmaking, this one single medium could only be the photographic medium of the image.

In order to record and reproduce sound through image, sound vibrations must be converted into light oscillations strong enough to sensitise a photographic emulsion, and for the projected image of the light shining through the photographic recording to be converted back into sound vibrations.

In the 1890's, different electromagnetic systems, such as the Oscillograph invented by Auguste Blondel[112], would make it possible to record the oscillations of a beam of light reflected from a mirror which vibrated in response to the loudness of the sounds picked up by a microphone.

In the early 1900's, it would become possible to reproduce photographic sound recordings using a selenium crystal as a photosensitive cell which converted the light oscillations in variations in the strength of an electric current.

Starting in 1906, Eugene Agustin Lauste began working on the development of systems which would make it possible to film sound and images simultaneously on the same medium. Lauste developed a 35mm camera which

111 In fact, these motors have continued being used for synchronizing sound studio equipment.
112 See: Claude Lerouge, "Sur 100 années, le Cinéma Sonore", Éditions Dujarric, Paris, 1996, p 45 - 46.

used one half of the filmstrip to film a small square frame (12cm square) every four perforations, reserving the other half for recording a sound track variable in area. Sounds and images were recorded together live. For copy-making purposes, this medium was kept intact, and although this medium were to break and its continuity to be lost, the synchronisation would remain intact - but the sound quality was quite low. The lack of devices making it possible to amplify the recording power and the highly limited sensitivity of the selenium photocells made it necessary for the sound track to take up half of the filmstrip and caused the mechanical inertia of the electromagnetic sound recording device to be less sensitive for high-pitched tones. Additionally, the Lauste sound reproduction system could only be used wearing earphones.

Despite all its problems, this system worked, and the Lauste films would introduce some of the permanent characteristics of all filmmaking sound systems:

- As a result of the image and sound having to be recorded at the same time using different devices, they are spaced apart from one another on the filmstrip.

How far apart they would be spaced (advance) and the relative position of sound and image would not be standardised until 1930.

In 1918, four German researchers, J. Engl, J. Masolle, H. Vogt and G. Steibt, founded the Triergon company and registered a number of patents based on the application of the triode valve to all stage of photographic sound recording and reproduction [113]. The Triergon system was presented publicly in 1922.

Starting in 1919, Lee de Forest would also begin developing a motion picture sound system based on different applications of his valve. He would use the triode to amplify the signal produced by the microphones. He would design highly sensitive gas ignition lamp preamplified by the use of a high-strength mains current, on which the modulation produced by the microphone had an effect. The exciter created a narrow recording (variable density) which, after being "read" by the photosensitive cell, was re-amplified by means of triode valve up to the point of making it perfectly audible. On April 15, 1923, De Forest presented his Phonofilm system. In this system, the sound was recorded with a twelve-frame lag behind the image.

F. 116
Phonofilm

The Fox-Movietone system was presented publicly in February of 1927. Theodor Case, who, as of 1925, would develop this system[114], would set three of the fundamental characteristics of sound films:

113 In the Triergon sysem, the image format was exactly the same as that of the 35mm silent films, but it used 42mm-wide supports (assymetrically perforated for 35mm) on which the added surface area, located outside of one of the rows of perforations, would be for the sound area.

114 Case had collaborated with De Forest on the invention of the Phonofilm.

- The filming speed of 24 images/second (456 mm/s)
- The separation and position of the image and sound recordings, establishing a advance in which the 20 sound frames were ahead of the image
- The 1.93mm width for recording the variable area tracks

These three parameters would later be accepted on an industry-wide basis.

In the Lauste, Triergon and Fox-Movietone systems, image and sound were recorded on the same negative, and it would be regarding this aspect that the other fundamental contribution which Lee de Forest would make to the working structure of filmmaking sound recordings would be focused.

The Phonofilm system produced a variable density recording, and De Forest decided that in order to achieve better-quality final copies it was necessary to record the image and sound negatives separately in order to process each individual negative in accordance with their own individual contrast-related needs.

This two-negative structure, one for sound and the other for image, also turned out to be necessary for the purpose of moving beyond the staggering between sound and image and retaining synchronisation by means of the editing processes.

By around 1930, all motion picture sound systems had unified their main features. In the 35mm films:

- Sound and image were being photographed on separate negatives.[115]
- The area reserved for sound on copies was less than 3mm in width.
- The modulated area was 1.93mm on the variable-area tracks and 2.54mm on the variable-density tracks.
- Reading was done on a column measuring 2.13mm in width.
- For negative editing and on copies, the sound marking is positioned 20 frames ahead of the synchronised image.

3.313.1 - Optical Sound Track Classification

Dozens of optical sound systems have been used in the motion picture business, but as of 1930, the industry has been progressively setting standards for making sound track projection standards compatible with one another. However, some differences do exist among these systems which are important to notice, because they have a bearing on the quality of the sound reproductions which must be achieved when films are shown.

Apart from this, several sound negatives have sometimes been prepared for one same film, or copies have been made the characteristics of which vary depending upon those of the projection equipment used on the circuits on which they were intended for use. Thus, for example, special copies have been prepared for very large theatres in which the sound advance was less than 20 frames[116], or sound tracks have been prepared in "conventional" systems for

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115 The Philips-Miller systems is an exception to this process, because the sound original was not a photographic negative. In the Philis-Miller sysetm, the sound recording was producted by means of cutting a recording (as on gramaphone records) on a film coated with an opaque layer, on which, using a ruby stylus, a groove proportional in length to the loudness of each sound moment was traced, achieving a transparent track similar in characteristics to those of a two-sided optical recording. The copying was done standardly. In the opinion of some technicains, such as Claude Leroude, the Philips-Miller was the system which achieved the finest recording qualities prior to the introduction of magetic tracks.

116 In keeping with the sound speed, the sound advance is calculated so that the synchronization will be

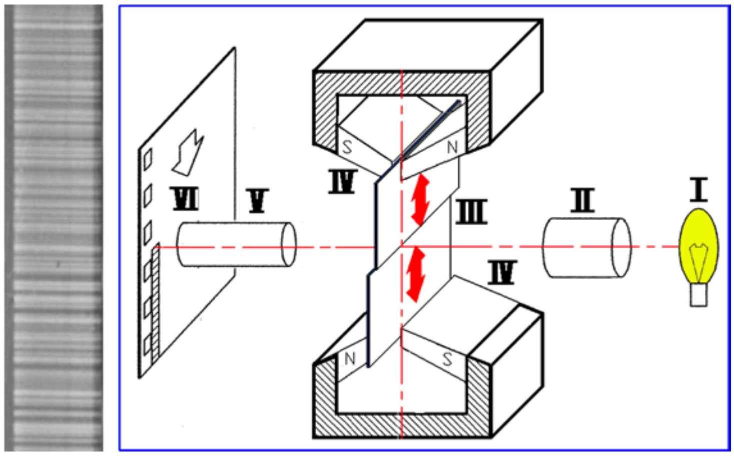
motion pictures filmed using special sound systems, such as "Fantasia" (the main premiere showing of which was done with a Fantasound track) or like those filmed in Cinescope with four magnetic tracks which have been shown using systems which were not even stereophonic.

In principle, when inspecting motion pictures for their classification (for restoration, it will be necessary to determine the characteristics of the system exactly), the identification can be based on the photographic and morphological characteristics of the tracks, on the markings on the tail/guide (leader) assembled at the end of each roll and the information included in the credits.

3.313.11 - Variable Density or Variable Area

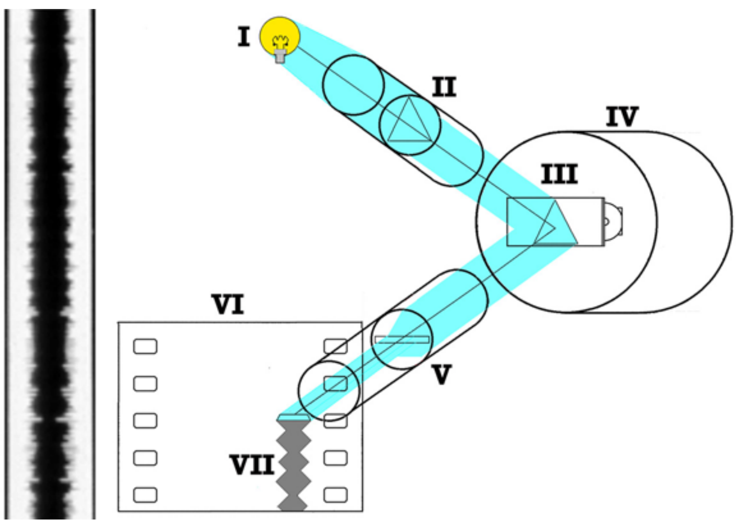
Based on their photographic characteristics, all tracks can be classified as either one of two types:

- Variable-density tracks
- Variable-area tracks



F. 117
Variable Density Type
(I)Light source.
(II) Lens.
(III-IV) Type Western-Electric valve.
(V) Lens.
(VI) Film.

For variable-density tracks, the sound track is of the same width throughout the full length of the film (due to which these systems are usually described as "fixed width" films), but the intensity of the light which is shown on the film at each given point in time varies - in keeping with the changes in loudness of the sound modulation - producing an image of greater or lesser density. On these type of tracks, the photographed image is seen as a number of crosshatches of different thickness and densities.



F. 118
Variable Area Type.
(RCA)
(I)Light source.
(II) Lens & Catch.
(III-IV) Mirror & Galvanometer
(V) Lens.
(VI) Film.

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exact towards the center of an average theater (estimated at around row nine in the stalls). In very large theaters, the viewers seated in the last rows in the back may notice a lag in synchronization.

For the variable-area tracks, each crosswise section of the photographed recording is shown on the screen divided into two areas which vary in width but are constant in density. One of these areas is of the maximum density (opaqueness) which can be achieved photographically, whilst the other area is transparent. The changes in loudness of the sound modulation are reproduced by means of the variations in the relative width (used surface area) of each one of these areas.

Both of these types of tracks must be recorded on very fine-grain films, but, while fast, high-contrast emulsions must be used for the variable-area tracks, medium sensitivity films processed at a very low-contrast gamma value are used for the variable-density tracks. The variable-density tracks are no longer used.

Photographically, digital systems must be considered as being variable-area systems.

3.313.12 - Analogue or Digital

Up until 1992, when Kodak presented its CDS system (which would not make it through the experimental stage), all optical sound tracks could be described as analogue recordings, in which the variations in loudness of the original sound corresponded exactly to the variations in transparency of the photographed track.

In the digital systems, the sound is not recorded as changes in transparency, but rather is encrypted under a graphic display of the digital analysis of the sound frequencies and intensities. The projector scanning heads decode this graphic display and reconstruct the intensities and frequencies of the original sound.

The digital tracks are located outside of the area set aside for the analogue track, with which they are therefore fully compatible.

Two types of digital tracks and a time-code track are currently used. Very often, the three types of digital tracks are used all at the same time on one same motion picture in conjunction with the analogue track.

F. 119 – Digitals Systems
[1] Analog stereofonic track. [2] Dolby SR-D. [3] Sony SDDS [4] D.T.S. continuity code.

The Dolby SR-D system tracks are located in the spaces between perforations on the same edge as the analogue sound area. The Sony S.D.D.S. tracks are positioned on the two edge areas of the filmstrip.

The time code tracks do not include a sound recording, but rather command the forward movement of a CD containing the motion picture sound track. On being located on the film they make it possible to instantly recoup synchronisation, thus overcoming the discontinuity caused by splices. In the D.T.S. system, the code is a broken line positioned between the analogue sound area and the image area. [117]

The digital systems being compatible with conventional analogue tracks makes it possible, using projectors equipped with the suitable reading heads, to

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117 In the aforementioned work, Claude Lerouge describes a French time-code track system, the L.C. system, in which the code track is `positioned in the edge area on the sound side.

be able to select the tracks to be reproduced and automatically switch over to the analogue track if any problem were to arise while the motion picture is being shown.

These tracks are put on very fine-grained, high-contrast films, which makes them totally compatible with those used for copies.

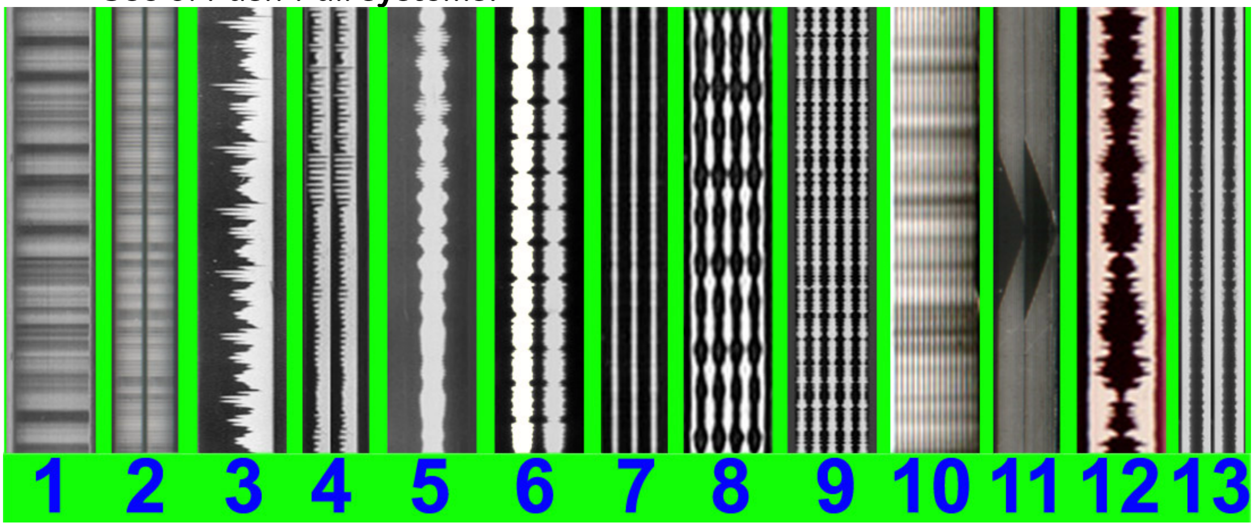
3.313.13 - Analogue Tracks Structure

For most of the systems, recording is done simultaneously on several tracks, which, with the exception of stereophonic analogue tracks and those produced using push-pull systems, are exactly alike.

When classifying this morphological aspect of the optical tracks, models which are spin-offs from that which was set by the Hollywood Academy in 1937 are usually followed:

This classification takes in:

- The number of tracks
- The direction toward which the dynamics move on the variable-area tracks
- Existence of noise-reducing devices and some added features
- Use of Push-Pull systems.



F. 120 - Clasificación morfológica de las bandas de sonido

1 – Variable density (type: Western Electric). 2 - Double track variable density (16mm). 3 – Variable area unilateral (Type: RCA). 4 - Double unilateral (16mm). 5 - Variable area bilateral (Type: RCA). 6 – Double variable area bilateral (Type: British Acoustic). 7 – Three bilateral tracks (16mm). 8 – Multitrack (Type: MGM 5 track). 9 – Multitrack (Type: Tobis KlanFilm 7 track). 10 - Multitrack (Type: Laffon-Segas 14 track). 11 – Double multitrack (16mm) 12 - Duplex. 13 - Double Duplex (16mm)Most of the density tracks are comprised of one single track, although there were also some two-track ones.

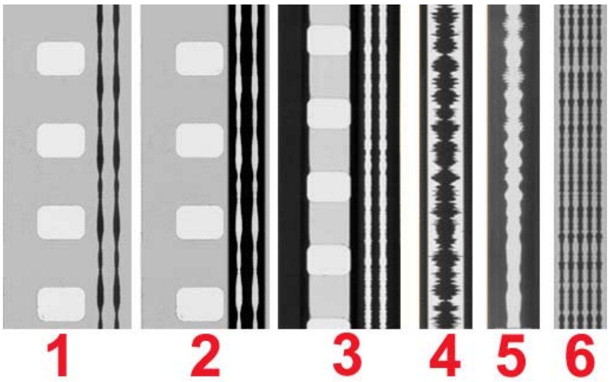
The variable-area tracks include single track (one-track), double-track (two-track) or triple track.

The term "multi-track sound track" is usually employed solely for those of systems such as the Tobis-Klangfilm or the Laffón-Selgas systems, which respectively incorporate seven and fourteen tracks.

On the area tracks, the recording dynamics move in the direction of one or of both sides of the lengthwise axis of each track.

The single-track system developed by RCA is a typical example of one-sided or asymmetrical systems.

In this type of recordings, the amplitude of development of the recording, requires a mechanical inertia which produces a lack of frequency responses over 5000 cycles, it is why they were replaced by symmetrical single-track or multi-track systems that, by reducing the length of development of the movement of the recording slide, provide better modulation responses.

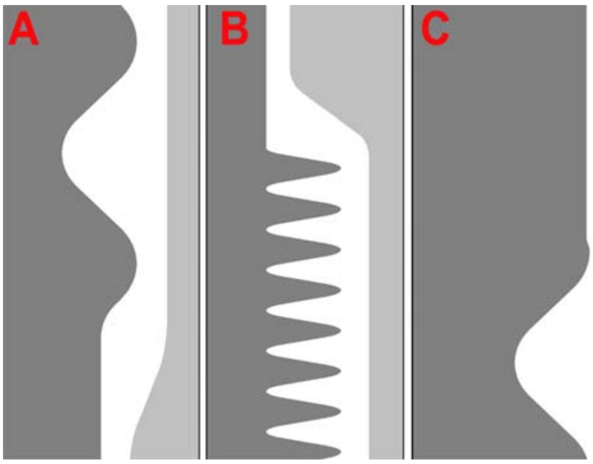


F. 121 Negative & Positive in sound tracks
In the morphological classification of the variable area tracks derived errors of a faulty observation of their characteristics can take place in negative and in positive.
[1] In negative: The tracks appear opaque and surrounded of transparent areas. [2][3] In positive: The tracks become transparent.
In some cases, a positive duplex [4] it can be erroneously described as positive bilateral [5]
Or, a negative Tobis Klang-film of seven tracks [6] it can be described as of five tracks.

The need of reducing the "noise" caused by dust and other microscopic damage which alter the transparency of the track is the reason behind many of the changes made in the optical sound systems.

Sound reducers decrease the transparency of the tracks during silences and are able to reduce the sound effect of the microscopic damage.

For the density tracks, the systems used reduced the average transparency (producing a controlled blur of density on the copies) or on the width of the track ("squeeze" or "matted-track" type tracks).



F. 122. Reducers noise in variable area tracks.
[A] In neuter position (silence) the border of track was located on the axis of the registration area and the dynamics sound developed symmetrically in both addresses. The reducer of noise was endowed with a very high mechanical inertia and never covering more than a third of registration area.
[B] The silence position stayed very low and dynamics sound was developed toward the opposed border.
[C] The impulse of the reduction mechanism it added that sensor of the registration mechanism, elevating the border on the edge of the sound area.

In the area systems, many different types of reducers were used, which were generally based on the use of a second set of shutter strips (which also follow the impulse generated by sound modulation, but with a major inertia response) which "shuts" -masking - the transparent area when there is no modulation on this second pulse.

Duplex tracks were used by numerous systems due to the quality and simplicity of their noise reducers.

In the two-sided, two-track sound track systems (which British Acoustic initially launched), the negative sound recording is made on two tracks which are reduced to two very thin lines for the silences and which are the only transparent areas on the positive copies. Therefore, the recording becomes its own noise reducer. This type of sound tracks has finally been adopted on an industry-wide basis.

Figura 123
Unilateral track with noise reduction and dual track with noise reduction type British Acoustic.

The systems known as push-pull systems were used (mainly in the U.S.) until when, c. 1950, the use of mag stock for the entire sound track production stage became widespread.

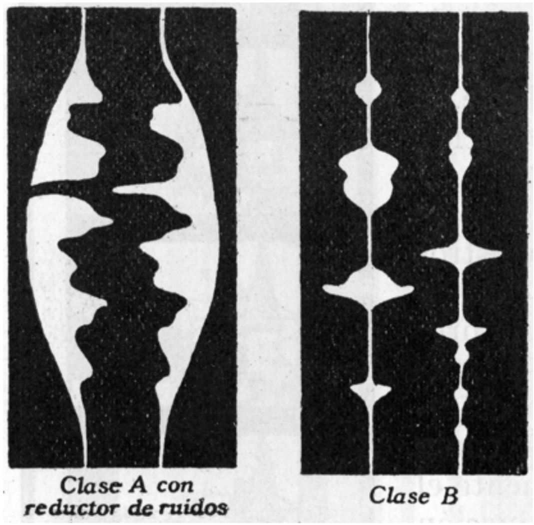


Figura 123
Push-Pull tracks
Track “A” type with noise reduction and track “B” type.

These systems recorded on two sound tracks of opposite counterphases, achieving major improvements in modulation and reducing distortion.

In these systems, the amount of light transmitted at each given point in time remains constant (because the light transmitted by one track exactly offsets that which is transmitted by the other), which makes it necessary to use a reading head equipped with two cells - closely adjusted to one another - capable of separately reading each track and reproducing them in phase.

The push-pull system did not meet with film showing success due to the need of revamping the projectors, but it was widely used in making the recordings and reproductions necessary up to the making of the sound negative.

3.313.14 - Optical Stereo Sound Systems

The first trials aimed at inventing optical stereo sound systems began in 1931, but due to quality-related problems or the need of adapting theatre reader and amplification systems, the optical stereo systems would not come into widespread use until 1970.

Abel Gance presented a stereo version of his "Napoleon" in 1935, but this attempt would never make it past the premiere showing. In 1940, Disney presented its film "Fantasia" using the Fantasound system, four double tracks in counterphase positioned across the full width of a 35mm filmstrip. This stereo version would only be shown in some theatres, and this system was never used again.

Starting in 1970, Dolby developed a system in which, using preamplification systems and "Dolby" filters for noise control, four stereo magnetic tracks (left, centre, right and ambience) were recorded, which, on the negative, are spread over two two-sided variable area tracks. The two tracks differ in their dynamic progression and must be read by two separate cells.

The Dolby system also required the revamping of theatres, after the successes achieved by the magnetic systems for large-scale formats - and with the competition of television - the industry would undertake these changes.

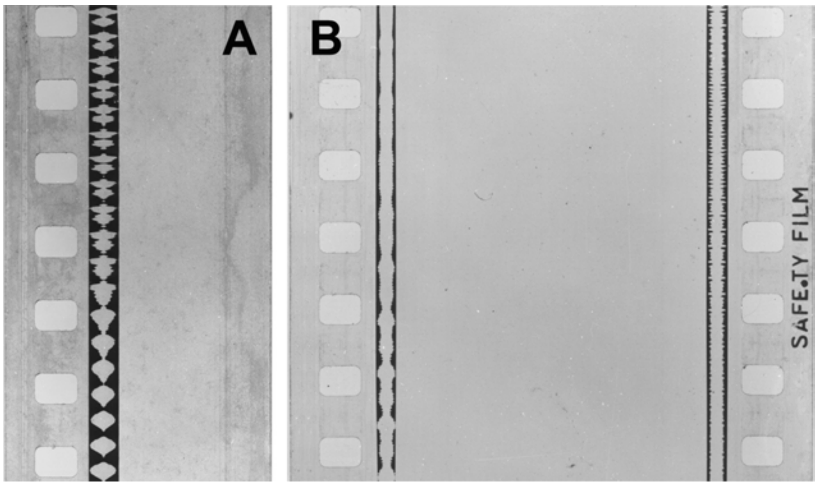
All digital sound systems - both optical and magnetic - are stereo systems.

3.313.2 - Optical Sound Conservation

From the very start, the very existence of sound negatives doubled the amount of stock comprising the original of a motion picture and, hence, the number of problems which to be solved for the conservation of each film.

Sound negatives are made on supports of the same gauge as the copies[118]. Nevertheless, up until the 1950's, due to the lack or high cost of raw stock, the practice of using each roll of 35mm film twice became widespread. Two systems were introduced to afford the possibility of this reuse.

The most widely used of these systems consisted of using film cut into two 17.5mm strips[119], whilst in the other system - known as the "double-track", “up &down” or “doublesided” system, the same roll of film was used twice, recording the sound on each one of the edges of the stock running in a different direction.



F. 125
[A] Negative cutted to 17’5mm.
[B] Double track record.

During the sound track production stages, which, prior to the introduction of magnetic supports, used up tremendous amounts of stock, these system could be fully justifiable, but in many countries, this system would spread to the original sound negatives per se, giving rise to highly serious conservation problems. The 17.5mm films, with the single row of perforations, are much more delicate than standard film. The two-track films must run through the

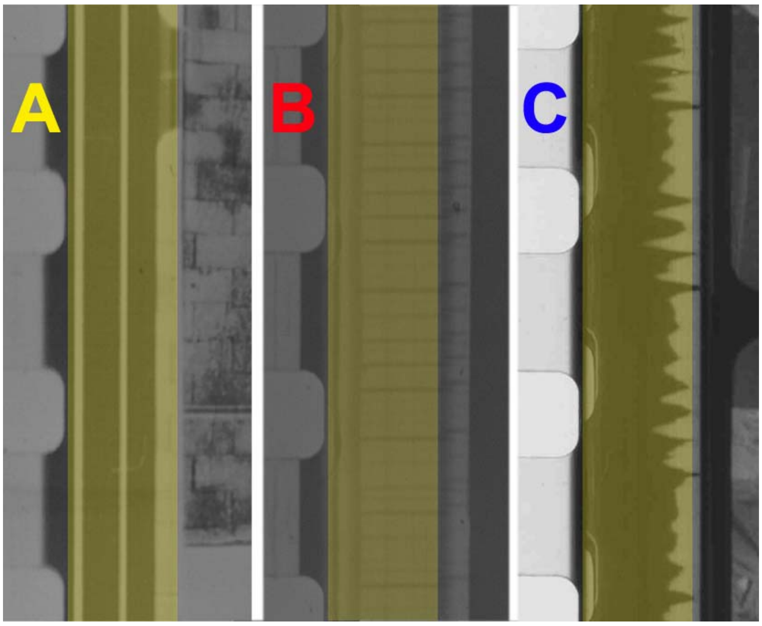
118 In systems like the Super 16mm system, in which the copies are made from an enlargement of the original negative, the sound negative gauge is not the same as that of the original image negative, but rather is the same as that of the dupe negative reproduced for making copies.

119 The widespread use of this system led to the manufacture of film in this gauge variation and of machinery equipped to take this film.

reproduction machinery twice, doubling the risk of breaking and risking damaging two sound tracks every time a incident occurs during the reproduction process.

The effects of the damage to supports and emulsion may have very different consequences for the reproduction of images and of sounds.

Contraction has quite a major bearing on sound reproduction possibilities. Lengthwise contraction may even prevent the sound negative from being fed continuously during reproduction, and crosswise contraction can cause any of the negatives to shift position and make the sound be reproduced outside of the reading area or lead to the image being placed in the sound area. These problems are especially serious when the stock available for the conservation of a motion picture is shoddily made copies, and classifying the type of sound track found on each stock can be of great help for planning reproductions.



F. 126
Movements in the sound track in relation with the shrinkage of the material used as the original for the duplications. (The standardized position for the reserva de sonido is marked in yellow).
[A] The picture enters in the sound area.
[B] The reproduced perforations enter in the reading area.
[C] Part of the record is outside of the sound area.

Changes for the worse in transparency (staining) caused by moisture, by chemical degradation, by growth of micro-organisms or damages or simple accumulation of dirt, can cause very serious damage (noise) to sound tracks, and the possibility of this damage affecting the sound increase when the sound tracks are positioned near the edge of the filmstrip.

F. 127: Stains in negative

The development of the sound track production and editing techniques would have a positive effect for the conservation of original sound negatives.

Except during the beginning years of sound films[120], the original sound negatives are not directly comprised of the original recordings made during the filming process.

The need of mixing sounds recorded from different sources and of giving each sound source the required highlighting and dramatic impact led to the original negatives being stock reproduced from previous recordings and to it being possible to record each roll of negative complete without any splices. No splicing being involved makes sound negatives much sturdier stock than image negatives.

The implementation of the magnetic systems for the sound production stages led to the original negative becoming simultaneously the first-generation optical sound stock and a reproduced stock. Apart from this, as the implementation of magnetic supports coincided in time with that of the safety supports, the synchronised tracks and those prepared on flammable supports were massively destroyed.

Fading colour is not a problem for sound tracks. The negatives are made on B/W emulsions and, on the copies, the B/W sound image must be conserved (along with the colour layer images) to make the bands of the density necessary for reproduction purposes.

F. 128
During the processing, this sound track was wrongly covered with the viscous developer that should recuperate the silver image to obtain the necessary density for the reproduction; now, with the coloured image almost totally deteriorated, this difference of densities clearly stands out.

3.313.3 - Magnetic Sound in Photochemical Filmmaking

As of the 1950's, magnetic stock has been used throughout all sound production stages and, in some specific cases, also as a motion picture screen sound support.

The 35mm, 16mm and 17.5mm perforated magnetic films afford the possibility of synchronising image and sound, being using throughout all of the sound track recording, editing and mixing stages up to the point of obtaining the original sound negative.

The magnetic perfored 16mm films were used to a very great extent for newsfilms and documentaries to be aired on television, which were filmed and assembled on reversal camera film and were synchronised with separate magnetic sound tracks.

In the original three-screen Cinerama, the six sound tracks were located on a fourth perforated 35mm magnetic support.

The smooth magnetic tapes (unperforated) in open one-inch or two-inch

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120 Sound editing techniques were developed at some times more than others throughout the 1930's, and their development process may have involved wideranging characteristics in each individual country.

cassettes have been used for studio multi-track musical recordings. Three-eighth inch tapes have been used for recording special effects and background tracks. To ensure synchronisation, these recordings had to be reproduced on perforated film before being incorporated into the sound track.

Currently, DAT type digital system magnetic cassette tapes area used throughout all sound production stages, completely replacing perforated tapes and providing the possibility of serving as originals for making the sound negative.

Magnetic tracks known as stripes, adhered to photochemical films started to be used almost immediately[121], both for professional filmmaking and within the scope of narrow-gauge films. Depending upon the type of use, the stripe may be applied to one side of the film or the other, before or after processing. This stripe is used on positive copy or reverse camera films.

For 35mm film, working copies with adhered magnetic tracks have been used in sound studios for preparing dubbed versions. These copies for dubbing commonly have two magnetic sound tracks (adhered to the edge tracks) and the conventional optical track.

Some manufacturers have supplied 35mm film with a wide magnetic band which takes up the entire optical sound area.

The first Cinemascope copies were made on film equipped with four magnetic tracks and "AC" perforations.

Magnetic tracks are the only sound support used on the 70mm copies.

It is on the narrow-gauge supports that striped films have been used to the greatest extent. In 16mm, striped reversal films were used to a very great extent in filming TV newscasts up until the time when portable video camcorders started being used on a widespread basis. Despite their sound editing-related shortcomings, striped reversal films could provide high-quality images and sounds at the fast rate which is absolutely essential for television newscasts.

For both the 16mm as well as the 8mm gauges, striped stock has been used very frequently for making sound copies for use on special circuits, from educational films to pornographic films.

For Super 8mm, although standards do exist for making copies with optical sound, the striped films have been the ones most used. For the Double 8 (Standard 8) films, striping done after the processing has been the widespread approach for putting in the sound.

3.313.31 - Magnetic Sound Stock Conservation

The main reasons behind the destruction of the magnetic stock used in photochemical filmmaking must be sought in the type of working stock the perforated magnetic supports have and in the reuse of these supports for other further productions.

Making original recordings and the processes of creating the synchronous dialogue, music and effects tracks and of the mix tracks take up most of the magnetic stock used in photochemical filmmaking, and of all of these aspects, solely some music recordings (made on multi-track wide tapes which can be

121 Some manufacturers have marketed 16 mm negative camera film with magnetic tracking for use in producing documentaries.

used for editing the sound tracks on other supports) and the final sound track mixes are usually conserved for any number of years by the film studios.

In general, although with numerous exceptions, magnetic films on acetate supports are conserved in very poor condition.. As has previously been mentioned in the sections devoted to supports and emulsions, the metal ions of the magnetic emulsions can become catalysts of the chemical degradation of these triacetates. In most of these films, the triacetate embrittles and the adherence between the binder resin and the support weakens.

The tracks recorded on polyester or PVC in the 1960's and 1970's are now conserved in all true fidelity, even under ambient conditions demanding to a very small degree. Nevertheless, on the synchronised tracks recorded throughout those same years, on which triacetate image film was used for giving the track continuity in areas on which no sound was recorded, the interactions between the magnetic emulsion and the acetic degradation is almost totally destructive.

Striped films are very low-grade material for conservation purposes.

For affixing the magnetic paste to the plastic support of the film, as the paste cannot be spread as is done on solely magnetic films, a glue[122] must therefore be used and, due to faulty adherence or to the strains and changes in shape and size which the film undergoes, the track-to-support adherence may fail, leading to absolutely irreversal detachments.

Apart from this, wound striped films are inevitably irregular in shape. Although the film has sound tracks on both sides (or one sound track and another balancing one to balance the winding), the thickness of the track will separate the sides of the film between consecutive turns, thus facilitating changes in the moisture content of the emulsions and the buckling of the support and causing irregularities in the winding which may lead to very serious damage.

3.4 - Electronic Image Technology Systems and Formats

Following many experimental trials, regular television broadcasts began in 1937, in England. From 1937 up until 1956 - when the two-inch Ampex tape recorders came out - electronic image producers would not avail of any systems for recording their work live, but had to make some of the decisions which have most conditioned the development of the electronic recording systems and their compatibility and, which, due to the boom proper of the existing system, have not been possible to change.

The audio-visual market reached world-wide coverage during the 1950-1980 period, and the speed at which the technological changes took place and the pressures stemming from the tremendous economic interests at stake, have placed compatibility-related problems far above the existing possibilities for designing coherent preservation policies. All public as well as private archives find themselves forced to conserve stock in many different formats, for many of which no equipment is being marketed any longer, and the attempts at

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122 When the magnetic track is located on the emulsioned side, the photographic emulsion must previously be "scratched" in the area to which the application is to be made, which even further complicates stability related to the adherence of the magnetic track.

preserving the documents by means of transfer from the new formats come up against the impossibility of consolidating an archiving format.

3.41 - Television

The electronic image media were created and developed to be used on television broadcasts and, although they are currently used widely in computer systems and also in photochemical filmmaking, compatibility with television standards still continues to be a fundamental criterion for accepting new systems for the development of currently-existing ones.

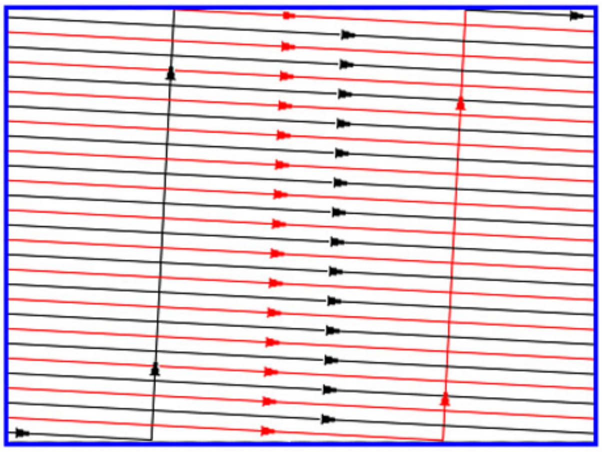
3.411 - Broadcasting Standards

The number of images per second and the number of "pixels" that comprise each image are the basic parameters of any moving image reproduction system.

On an empirical basis, it has been determined that visual perception distinguishes up to 48 light flashes per second. At slower speeds, the changes in brightness are perceived as flicker, which is more annoying the brighter the light.

Photochemical filmmaking employs revolving shutters in its projection equipment in order - by cutting off the passing of light through each frame two or three times - to double or triple the number of flashes produced from its 16 or 24 images per second.

In television systems, each image is picked up and transmitted in sequence, by analysing and converting each pixel comprising the picture into a signal, one by one and one after the other. To remedy the problem of "flutter" without having to film more than 48 pictures per second, an alternative strategy was adopted, that is, the image of each picture is broadcast broken down into two parts or fields, each one of which contains one half of the pixels of which the picture is comprises.



Thus, by splitting each image in two, television managed to combine the sequential feature of its image analysis and reproduction system (which breaks down each image into a number of dots and records and reproduces dot by dot, line by line) with the human eye's light perception-related needs.

In a sequential analysis and reproduction system, defining the number of pixels which will make up the image amounts to the same thing as defining the number of "scan" lines into which the process of analysing/reproducing each image will be broken down. The first English broadcasts were made on 405 "scan" lines per picture[123]. Regular U.S. broadcasts would being in 1939 with a 340-line system.

The greater the number of "scan" lines, the greater the number of pixels making up each picture, and the better the quality of the images. But also, at the

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123 As of the 8th of 1937, in the EMI system. Gordon White "Video techniques", I.O.RTVE, Madrid, 1989 - 2nd Edition. p. 15.

same time, the wider the signal bandwidth required for transmitting the information.

The signal bandwidth required for handling and transmitting the information became a factor limiting the quality of this system and would once again become a limiting factor for the design of colour systems.

The standardisation of the number of lines was an element essential to the success of television broadcasts and, in 1941 in the United States and in 1952 in Europe, agreements were reached for setting up systems respectively with 525 and 625 lines per picture.

To define the number of pixels that would make up each image, it was also necessary to fix the format (dimensions and proportions) of the screen on which the image would be displayed to the viewing audience.

Due to the logical starting limitations, the first test checks led to circular screens, but in the end, in the 1940's, television would adopt rectangular screens of proportions similar to those of the film projector: 4/3 = 1.33:1.
Different suggestions have been made with regard to modifying the screen format proportions, and the 16/9 (1.77:1) format is becoming progressively more popular and is very likely to be adopted for digital television broadcasts.

The definition used for "flutter" is combined with the "lined" structure of the electronic image, dividing the information into uneven lines and even lines. The systems "read" the uneven lines first and then the even lines, interlacing the image of both of these two field to put together a complete picture.

To achieve the perfect synchronisation of the two image fields, it is absolutely necessary that all of the devices in each system be functioning under the control of one same synchronisation pulse. To accomplish this, alternations in the flow of the mains current were employed.[124]

The alternating current flow characteristics employed in each country were adopted for reasons which have nothing to do with television and, generally speaking, had already been established before this problem arose. The European countries and the countries in their area of influence had adopted 50 cycle/second systems, whilst in the United States, Japan and many other countries, the 60 cycle/second system was chosen.

In the countries in the first of these two groups, the modulation of synchronisation by means of alternating current reversals would lead to frequencies of 25 pictures (50 fields) per second, whilst in the countries in the second group, the 25 pictures (60 fields) per second would be implemented.

The combination of all of these parameters led to the configuration of two broadcasting standards, that is, 525 lines at 30 pictures per second and 625 lines at 25 pictures per second. These two standards were accepted world-wide and, little by little, countries and regional agencies opted for one of these two standards, having continued the use thereof for the advent of colour television.

3.412 - Colour Systems

The colour systems used in television worked on the principles of analysis and additive synthesis with the primary colours red, green and blue.

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124 The electric current flow alternate frequency may undergo variations, but, at each point in time, is the same electric current which powers all of the devices in one same system.

By the time when colour television was first launched, the number of B/W television sets installed in some countries (mainly in the United States) made it necessary for colour programs to also be able to be received in B/W. This need completely conditions the development of colour systems.

In B/W TV, each pixel or dot of information is solely the brightness value of the image reproduced at that point, the advent of colour made it necessary, in addition to this brightness value, for the information necessary for determining the colour of each pixel to also be shown.

Due to the characteristics of the B/W systems in existence in 1950, the colour information had to be transmitted inside the brightness signal band, without the existence of two or more different signals on one same transmission band causing any interference among the signals.

Different systems would be developed throughout the 1953-1963 period, three of which would meet with acceptance on the market.

In 1953, the National Standard Committee (U.S.A.) approved a system known by this committee's acronym, NTSC. During the 1959-1961 period, the French SECAM (Séquential couleur à mémoire) would be gotten under way and, in 1963, the PAL (Phasen-abwechslungs-linie) system developed in Germany.[125]

These three systems are alike with regard to several aspects:

- They have two colour information signals on the same signal band as the brightness information.
- The colour information signals require a relatively narrow bandwidth and are transmitted added to the upper part of the pass band (subcarrier band).
- The colour signals (corresponding to red and blue) are known as "chrominance" and include a value coding for each colour in the total image brightness value.
- The brightness signal (known as "luminance" includes the total brightness of the three colour images, being possible to be received in B/W, reproducing the image in grey values.

Additionally, in these three systems:

- The chrominance signals do not include any actual brightness information.[126]
- In the colour synthesis which takes place on reproducing the image, the value for green is restored by comparing the sum of the values coded for red and blue with the total value of the luminance signal and assigning green the value of the difference in question.
- The luminance signal includes the total image brightness value and does not include any colour information.
- When the filmed image has no colours, the value of the chrominance signals is nil.

Despite all of the similarities listed above, these three systems are totally incompatible with one another.

3.42 - Electronic Image Recording Formats

125 Other systems were developed but would never meet with market acceptance.

126 In other words, the intensity of each one of the chrominance values cannot be converted into luminance by the screen devices, depending upon the brighness of each pixel, exclusively, of the brightness information included in the luminance signal.

The recording format is the fundamental characteristic of any electronic image support.

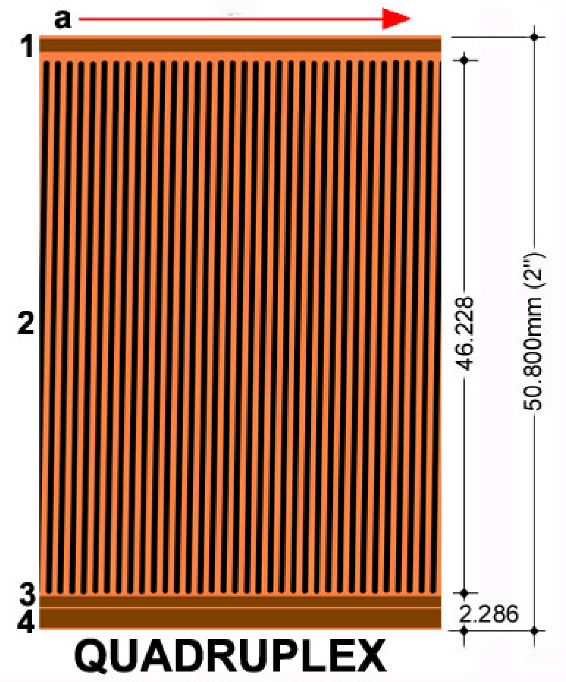
In the electronic image systems, the pitch concept is not as important as it is for photochemical supports. Although the tapes in each video format are of certain set dimensions, the fact that tapes of two different recording formats are of the same width does not make them any more compatible with one another.

Just as for the photochemical filmmaking supports, in the electronic image recording system, the format concept is related to how the image is arranged on the support, but, due to the fact that these are images which are not visible on the support to the naked eye, each one of the electronic image formats can arrange the images on the support in keeping with radically different layouts and sequences.

Around 1990, a new type of format based on the digital coding of the information first started being introduced. The development of digital systems opened up a new way for electronically recording images, there currently not being any possible feeling as to the limits of these systems.

3.421 - Analogue Formats[127]

The Quadruplex format, designed by Ampex and also adopted by RCA, employs a tape measuring two inches in width (50.8mm), on which the video signal, an audio track and a synchronism control track and other cue track are recorded.



In this system - known as "cross recording" - the tape moves at a speed of 39 cm/s, and the recording is made by means of four heads located on a roller revolving in a direction perpendicular to the tape axis.

The tape speed is constant, but the drum speed varies depending upon the mains current frequency, that is, 250 revolutions/second on 60-cycle current and 240 revolutions/second on 50-cycle current. The combination of the tape and cylinder movements leads to the crosswise slant of the recording tracks varying, adhering to the adopted standard, and therefore, the recordings made using one line scheme or the other are incompatible.

Figura 130 - Quadruplex
[1] Audio track. [2] Image area. [3] "CUE" track. [4] Control track. [a] Tape movement.

Between each video track, there is a safety zone (guard track) for ensuring the individualised scanning of each section of the track and for reducing the magnetic interaction between the signals recorded on adjacent tracks.

127 Some of the data included in this section have been taken from the presentation made by José Antonio Rodríguez in the First Movie and TV Archive Meeting held in Madrid in 1995, published in: "Textos del VI Seminario/Taller de Archivos Fílmicos". Electronic edition, Spanish Film Archives, Madrid, 2001).

The sound track and the synchrony pulse track are recorded, by means of fixed heads, and the cue track includes the time codes and other additional information.

To date, Quadruplex is the only video format which, although it were to only be for twenty years, has managed to be considered to be a standard accepted world-wide.

F. 131
Transverse Record
Head of two inches video recorder Ampex AVR-1.

Starting in 1970, the professional corporations (the SMPTE or the UER) promoted the development of lighter, higher-capacity recording systems, which were indispensable, both for greater equipment mobility purposes as well as for meeting the needs of the colour systems.

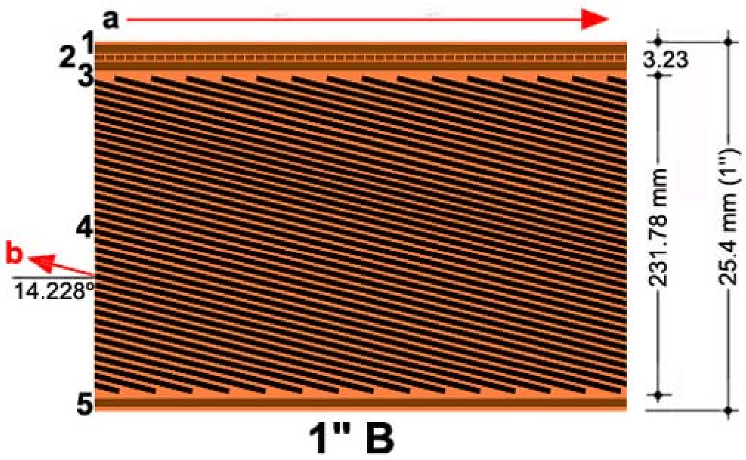
The "B" and "C" formats that use one-inch tape were the first answer to these needs.

For the one-inch formats, the drum on which the recording heads are located is slanted on a certain angle from the tape axis, marking off very long parallel tracks.

This type of recording, referred to as "spiral", has been adopted by all of the later formats, and the direction, angle and length with which the tracks are recorded on the tapes all depend upon the recording head drum diameter and slant and vary for each format.

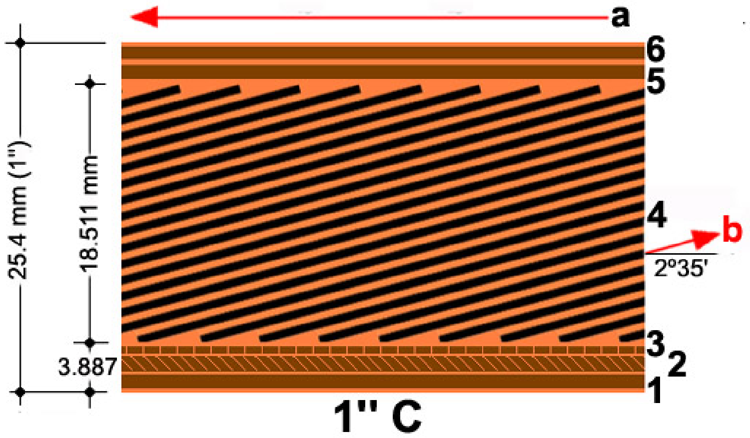
Figura 132
Head of a video recorder Bosch BCN-51

For the "B" format, the tracks are recorded from right to left, over a length of 80mm.



F. 133
1 inch B Format
[1] Audio 1.
[2] Control track.
[3] Audio 2.
[4] Image area.
[5] Audio 3.
[a] Tape Movement.
[b] Registration angle.

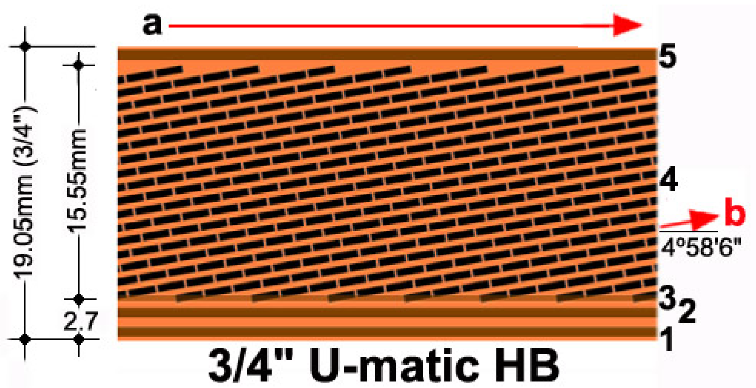
In the "C" format, the recording is done from left to right, with a development of 400 mm.



F. 134
1 inch C Format
[1] Audio 3. [2] Sinchronism track.
[3] Control track. [4] Image area.
[5] Audio 1. [6] Audio 2.
[a] Tape Movement.
[b] Registration angle.

These two formats are naturally totally incompatible with one another.

The tapes used for the U-matic formats incorporate one fundamental characteristic for their handling and conservation, which is that they function inside cassettes.



F. 135
U-matic HB
[a] Tape Movement.
[b] Registration angle.

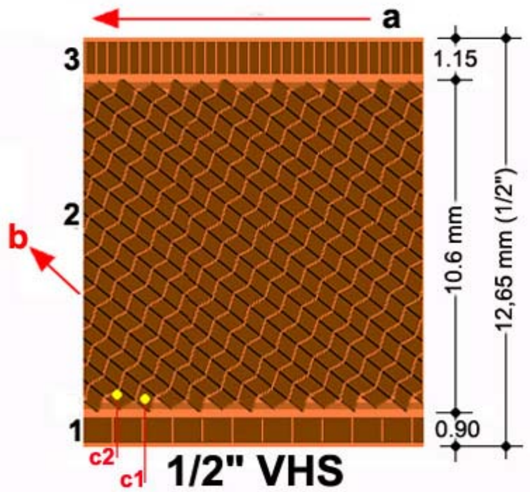
U-matic (similarly to that of the 16mm films) first came out as a low-band format intended for semi-professional uses, but its manufacturer and owner, Sony, managed to develop it up to the point of meeting television newscast needs. The U-matic HB format achieved a recording quality, which, although not as high quality as the one-inch formats, was highly satisfactory considering how lightweight these systems are.

U-matic would also bring to fore a new type of incompatibility among electronic recording systems, which is that the format is modified for each new generation, allowing the existing tapes to be reproduced on the new systems, while those recorded on the new systems cannot be played on the earlier systems.

This "contribution" to incompatibility, started by the U-matic LB, U-matic HB and U-matic SP formats has been continued by other systems.

Cassette tapes were fundamental to the development of home video systems, which started becoming popular in the 1970's. The open reel-wound tapes were too tricky to handle for non-professional uses.

The three home video cassette formats, the Philips VCC (Video2000), the Sony Betamax and the Panasonic VHS, although strictly incompatible, have many aspects in common.



F. 136
VHS
[1] Control track. [2] Image area. [3] Audio.
[a] Tape movement. [b] Registration movement.
[c1-c2] Head tracks 1 - 2.

All three of these formats employ 1/2" (12.65mm) tapes and, to make better use of the tape, did away with the safety divider (guard track) between video tracks.

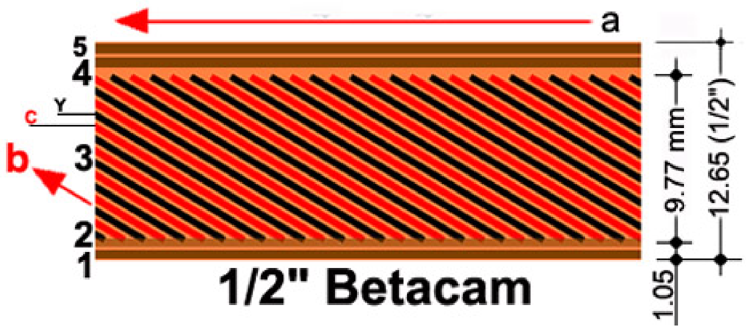
Doing away with the guard tracks made it necessary to develop dynamic control (tracking control) systems to ensure the tracking of each section of the recording track by the scanning head. These systems have also been implemented in professional equipment. There being no guard tracks reduces the signal retention possibilities in this type of formats.

The VCC format (possibly the best of the three) stopped being manufactured due to commercial problems.

The Sony Betacam and the Matsushita systems are representative of the fourth generation of professional video formats.

In the Betacam format, which first came out on the market in 1981, the luminance and chrominance signals are recorded using different heads and on separate tracks. This procedure, known as recording by components (the earlier ones are now referred to as combined video systems), has later been used in most of the digital formats.

Betacam has two sound tracks and a control track, in addition to a time-control track.



F. 137: Betacam
[1] Time-code track.
[2] Control track.
[3] Image area.
[4] Audio 1.
[5] Audio 2.
[a] Tape movement.
[b] Registration movement.

The Betacam SP (Sony) and "M II" (Matsushita) formats first came out on the market in 1987, as further developments on the earlier formats. Both of these formats based their innovations on the use of metal emulsions. They incorporated another two audio tracks (in FM), which are recorded on the same spiral tracks by the colour heads.

In Betacam SP, metal particle or oxide tapes can be used, it being possible for the oxide particle tapes be also be used by the Betacam systems. The changes made in the "M II" format make it totally incompatible with its predecessor.

The Betacam SP particle tape recordings have shown themselves to have very good conservation characteristics.

3.422 - Digital Video Formats[128]

Except in the first Quadruplex versions (in which the editing was done by the cut and splice method), all of the video editing systems work on multi-reproduction, reproducing the elements selected from the original recording on new tapes. In this system, the loss of quality in the successive reproduction generations becomes of crucial importance.[129]

The international broadcasting organisations promoted the creation of digital formats for purposes including that of remedying the generation-related degradation problems on the recordings during the editing processes.

In the analogue systems, the analogy takes place precisely between the light brightness or sound loudness given off by the original source and the electromagnetic intensity generated by the recording devices. In the digital systems, the brightness/loudness information for each dot of light or each sound moment is processed and coded without the recording devices needing to modify the intensity of the electromagnetic signal they are producing. Therefore, the reproduction systems can "up" the intensity of the degraded signal and take a complete reading, such that the recording will retain a minimum (relatively very low) level of presence.

These formats additionally incorporate several automatic error and damage-correcting systems which contribute to the conservation of the recordings.

The "D1" system was the first digital video format to be commercially marketed.

128 Some of the data included in this section was taken from: Ignacio Salo: "The Evolution of Digital Image Supports as Related to Conservation Problems", a lecture given at the VI Film Archives Seminar/Workshop" in November 2000.

129 According to some technicians, in analog video sysetms and even using well-tuned equipment, recording degradation can be noted as of the third generation of reproductions.

This system uses one-inch tapes and brought in a new recording system concept, which is recording by components, by means of which the red and blue chrominance signals are processed separately, affording the possibility of making many reproductions one after the other with scarcely any signal degradation.

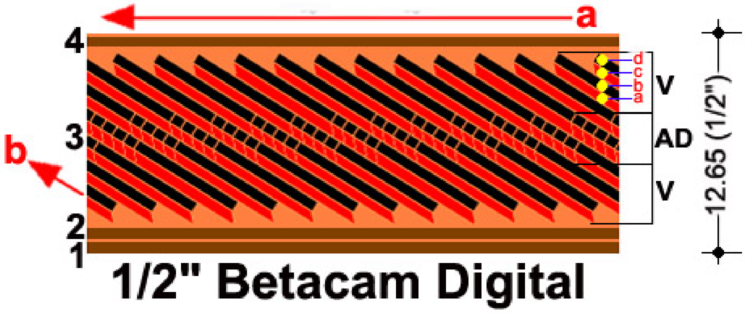
The "D2" and "D3" systems continued being based on the original combined video concept, which leads to the loss on reproductions of one generation after the other being more noticeable.

"D2" employs one-inch tapes, while the "D3" format uses 1/2" tape, this enabled "D3" to become the format in which the first digital camcorders were developed.

The Betacam Digital format was created based on the "SP" format and can "read" tapes recorded in that format.

Betacam Digital added another new term to professional video systems, which is the term "compression".

The formats equipped with compression make for major recording savings by doing away with the redundant signals. In professional video formats, several compression systems area used.



F. 138 - Betacam Digital
[1] Time-code track.
[2] Control track.
[3] Analogical Audio track.
[V] Image area, tracks a-b-c-d.
[AD] Audio digital.
[a] Tape movement.
[b] Registration movement.

The DCT (which is the basic system) analyses the frequency of each image element (pixel) and eliminates the adjacent repeated ones, replacing them by an expression of their frequency and of the number of repetitions. Betacam, which uses this system, achieves compressions of up to 2.2:1.

DV Compression, used in systems such as the DVCAM, provides compressions of up to 5:1, and the MPEG-2, which compares the differences among consecutive image fields - and can even record only these differences - provides compressions on the order of 10 es to 1.

Formats providing for compression are undoubtedly of major interest from the standpoints of the audio-visual studios, but they pose some major problems for the archives, as they are one step further along the paths of incompatibility and of conservation being dependent upon the equipment for the conservation of the recordings.

3.423 - Data Formats

The development of digital systems has led to a new concept coming into being, which is image recording in the form of data files which are capable of storing tremendous amounts of information and of being used in many different video formats or even of being converted into photochemical images.

These systems fall totally outside of the objectives of this study, but they are the future of moving image reproduction, and the audio-visual archives must devote special attention to them.

3.43 - Electronic Image Recording Conservation

For electronic images, the development of standards first began with the acceptance of two broadcasting standards and three colour systems.

As the colour systems and broadcasting standards are set out by each individual country, the audio-visual industry has been overcoming these basic incompatibilities (with some limitations) by means of devices which allow the conversion of recordings made under different standards or using different systems.

The recording formats went through an initial period of uniformity, as has been previously mentioned. Throughout a twenty-year period, Quadruplex (which was the only format at that time) was the standard accepted world-wide, but, little by little, the launching of new formats one after the other (making industrial developments which would have been impossible or much more costly using the earlier formats) created barriers between the recordings done in each format, and these new barriers were not being remedied on a country-by-country basis, but rather, on a studio-by-studio basis and even on a production-by-production basis.

The incompatibility among formats is actually an incompatibility among systems and reaches its height of seriousness when the conservation of the recordings beyond the obsolescence of their original formats or of many generations of different formats is involved.

The compatibility among formats of similar characteristics (formats which might be described as belonging to one same generation) is not a problem as long as the systems and tapes necessary for making reproductions are still being sold on the market. Likewise, as long as the systems necessary for "reading" the earlier recordings and the suitable connections and devices are available on the market, it will be possible for any recording to be reproduced on different formats yet of similar or better characteristics than the original.

But thousands of tapes belonging to four or five generations of professional video formats are currently being stored in television broadcasting system archives.

The recordings made in Quadruplex or in "B" or "C" have been and are currently being reproduced on new formats, and, in many cases, depending upon the point in time at which this reproduction has been done, they are conserved on formats as the U-matic, which has commercially disappeared, or that, as the Betacam SP format, have already starting to become obsolete and must be reproduced again on digital formats. And this is an endless chain in digital image. So many new formats are coming out on the market that not even the studio technicians can expect to have a detailed knowledge of all of those on the market.

SECTION TWO
Linking the Stock to the Motion Picture to Which It Belongs

Criteria for the classification of the stock

The classification of the stock that is conserved from a motion picture and the cataloguing of the motion picture in question are complementary yet different procedures. These are two procedures, which can only be carried out if those in charge of the cataloguing and of the technical inspection work closely together.

The archive cataloguing departments must determine the original characteristics of each motion picture, the possible existence of versions other than the original version or of several original versions and the technical procedures and stock used in making the picture, and all of these aspects must be taken into account during the inspection of each stock, in order to determine its linking to the motion picture to which it belongs.

4 - Linking the Stock to the Motion Picture to Which It Belongs

In the filmmaking industry, the concept of "original" has its own individual characteristics which differ greatly from those defining originals in most of the activities leading up to the production of stock which can be conserved in archives.

The original of a written, painted work, etc. includes the complete work and, in some of these activities, certain characteristics (such as the presence of original seals or signatures) are only found on the original. A written work is reproduced by printing, but it is complete in its original, to which one must refer for making critical analyses and editions. A painting or a sculpture are materials unique unto themselves, and whatever reproductions may be made are classified as "copies".

The original of a motion picture may not include the entire work[130], may be stock created by means of many reproduction processes and may solely be accessible by way of further reproductions.

In order to determine the exact relationship which each individual has to the work to which it belongs, three types of aspects must be taken into consideration:

- Filmmaking is an art form based on duplication, and each film, as a reproduction, has a definite relationship to the motion picture.
- Filmmaking is a complex industrial process, during which many different materials are produced - many of which are not representative of the motion picture in question or are only so of any one of its elements or characteristics - and it is a process which, throughout filmmaking history, has undergone many changes.
- The vastness of the realm throughout which professional films are shown makes the existence of versions and variations making substantial modifications in the characteristics of the original work practically inevitable.

130 As is the case of the original negatives in photochemical filmmaking, in which the brightness and color values are reversed and can be reproduced in very different ways.

Determining the relationship which exists between a motion picture and the stock available in the archive is an activity fundamental to motion picture conservation and must be carried out during the technical inspection made upon acceptance of all stock, even those from very recent productions.

4.1 - Systems for Determining the Generation-Related Status of Stock as Reproduction

Between the first complete original stock of a motion picture and the copies prepared for the showing of that film, there may be a whole string of stock and reproduction systems allowing the possibility of all types of changes being made - even by chance.

4.11 - Reproductions in Photochemical Technology

The chain of reproduction, the standard model of which had previously been specified in Section 2.142 on discussing the emulsions and the industrial duplication system, takes in many different variations and can be carried out by means of several duplication methods, entailing from zero[131] up to four or more stages and stock of a different generation-related status being involved in any one of these stages.

Although the original negative of a motion picture (or the reversal original positive, when this type of stock is used as a basis) cannot be considered to be a reproduction but rather the first complete original copy of each motion picture, in keeping with conventions adapted in layman's language, it can be said that the original negatives are the first-generation stock.

4.111 - Motion Pictures Without Reproductions

There are some types of stock which do not fit into the original and reproduction structure.

Reversal films afford the possibility of making originals which are also the stocks shown on the screen. These films made of one stock may be edited and incorporate magnetic tracks for sound or can even be synchronized with a sound material completely edited on perforated magnetic film; this kind of material is characteristic of non-professional filmmaking and very common in newsreels and newscasts made to be aired on television broadcasts.

The leaders and titles of most silent films represent a special case as regards stock, filmed according to the negative→positive system, but with negatives made directly with the characteristics of a positive (transparent characters on a dark background), reproducing them inverted (black characters on a transparent background).

4.112 - Single-Stage Reproductions: Original & Copy

In photochemical filmmaking, the original negative of image is often formed by multiples materials, assembled with splices, so it is a very delicate element. However, the commercial duplication system, eliminating the need of using the camera negatives for directly making release copies, turned out to be a fantastic tool for the preservation of the works.

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131 Such as on the reversal original positives.

Making direct copies from the original negatives still continues, necessary to obtain first check copies used to establish the grading values and, direct copies will sometimes also be made from the negative for the major premieres of the motion picture.:

Even if making copies from the original negative is a guarantee of photographic quality, it also can be a way of introducing errors during the reproduction if the data of the original grading are not conserved.

In filmmaking which is carried out for relatively small markets, making all the release copies from the original negatives has continued to be standard practice and, as mentioned in the section 2.142, gave rise to a very cruel form of the success paradox.

In the film archives, the classification of the stock is a complex activity that obliges to bear in mind the possible existence of variations, included for a simple structure as the single stage of reproduction.

- Reproduction can be made on reversal emulsions, giving a positive from another positive.

It is a general practice for narrow-gauge films, often used for television and industrial and educative filmmaking. In commercial filmmaking, it has been used for the reproduction of colour emulsions without integral masking.

- The reproduction can be made from negatives of a different generation-related status.

The negatives of many films present elements of archives used in previous movies.

On the other hand, since the development of the optical track reproduction systems made it possible to make mixes from different sound sources, the original sound negatives then became, simultaneously, the first photochemical element of the soundtrack and a stock made completely by reproduction.

- The original negative can be constituted by various elements to be reproduced together.

The films made with colour systems on B/W negatives (Dascolour or Cinefotocolor types), the Technicolor copies or the ones obtained from negatives assembled on bands "A" and "B", need this type of reproduction, also used to make fades out through in in some productions.

4.113 - Two-Reproduction Stages: Original, Duplicate and Copy

This reproduction structure is based on the use of reversal emulsions during the filming or in the first stage of reproduction.

- Reversal originals

Reproduction by means of a dupe negative is the recommended way to avoid unwanted absorption of dyes when making copies of motion pictures filmed on reversal emulsions without integral masking.

This system is also used when copies with optical sound must be made from reversal originals and when, due to the number of copies (silent or sound) which must be made from a reversal original, it is safer or more economical to use the negative→positive system.

- Reversal duplicates.

The Kodak emulsion "Colour Reversal Intermediate 5249/7249" made it possible to make direct negative duplicates from the original negative. Using this approach to duplication affords the possibility of skipping a stage in the industrial duplication process.

4.114 - Three Reproduction Stages: Original, Positive Duplicate, Negative Duplicate and Copy

This is the method of reproduction which allows the possibility to completely preserve the original negative and employ all of the variations that filmmaking distribution requires.

The sale of the film or its export to other countries can be made based on the positive duplicate made from the negative, or based on negative duplicates made without having to use the negative.

The sound negatives from versions other than the original version can be synchronised with the negative image duplicate made for that version.

In B/W, it is possible to combine sound and image on one same support, either in the positive or in the negative duplication stage.

Reduction to 16mm can be used in either one of the two stages of duplication, many negative duplicates can be made making it possible (by using supports with special perforations) to simultaneously make several copies on narrow-gauge supports.

Naturally, the four methods of reproduction mentioned only correspond to the processes established by industry; the restoration duplication, made from release copies, can lead to create sixth generation stock.

4.12 - Basic Elements for Determining the Generation-Related Status [132]

Determination and classification of the generation-related status of each material in the duplication process is a fundamental undertaking in order to evaluate the importance of this material for preservation and, in this case, the restoration of the movie to which it belongs.

The elements available for the classification of the generation to which reproductions pertain are extremely simple and are based on:

- The characteristics proper of the photographic process
- The study of the marks and markings placed on the stock by the raw stock manufacturers, by the editors and by the laboratories
- The knowledge of the characteristics of the reproduction equipment
- The effects of the damage and of the chemical degradation on each stock and on the reproductions made from this stock

To perform this task, the stock must be examined directly by hand. The only tools which are really useful are a rewinder and a good magnifying glass. Viewing on a viewing table ("moviola") or screening can be absolutely essential, but for other purposes.

It must always be kept in mind that the techniques and the stock used for filming or reproducing stock are constantly changing depending upon the technical development and the economic resources of the film studios.

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132 Harold Brown, in his work "Physical Characteristics of Early Films as Aids to Identification” (to which repeated reference has previously been made herein), would begin the study of these elements and would open up the way for constructing a scientific cataloguing system for filmmaking stock.

Thinking of the characteristics of the stock that is being inspected as if it had to adhere to the standard model at the point in time at which the inspection is being made is like wearing a blindfold and not being able to see the stock being inspected.

4.121 - Negative→Positive / Transparent→Opaque

On the negatives, the external reality is recorded by reversing brightness and colours, brightness being reproduced as opaque (black) and dark as transparent (white) and, with the exception of the variables resulting from the use of reversal emulsions, this formulation of opaqueness and transparencies - opposite the brightness and darkness of the external reality filmed - will be repeated in all of the uneven-numbered generations. In the even-numbered generations the brightness values will correspond to those of the external reality and will be of the characteristic defined as positive characteristics.

> The generation-based ordering on uneven-numbered negatives and even-numbered positives and the changeover between brightness and opaqueness are two elementary questions, but it is thereon which all of the possibilities of setting up a generation-based classification are based.

Nobody confuses a negative with a positive, but there are elements which have characteristics of a "positive" on any type of stock.

The edge marks and damage are some of the elements which are always of the same characteristics, whether they be on negatives or on positives.

4.121.1 - Edge Marks

Edge marks are placed on the edges of the film by the manufacturers. These marks are usually added photographically during the manufacture of the film, remaining as a latent image until the film is processed by a laboratory. Sometimes, the footage numbering (edge numbers) is added stamped in ink.

These edge marks may include manufacturer's trade name as well as other data for identifying the stock type or manufacture[133].

As of the 1920's, as the techniques used for negative editing were being developed, the manufacturers started adding a length measurement located every foot of film on the negative films and on many duplication films.

The footage numbering, generally comprised of letters and numbers, is reproduced on the copies in order to allow the assembly of the negative by following - with exacting precision - the stock and lengths marked on the cutting copies.

The reproduction of the footage numbering and, along with this numbering, of all of the other marks added to the edges has been a highly valuable and reliable source of stock identification and classification.

Both on positive or negative films for those added photographically or stamped in ink, the edge marks will always be comprised of black (or colour) markings on a transparent background on whatever stock to which they have been added[134].

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133 Some manufacturers add the stock manufacturing date by means of perforated marks at the beginning and end of each roll.This system is very common for narrow-gauge films.
134 Except for colour reversal masters.

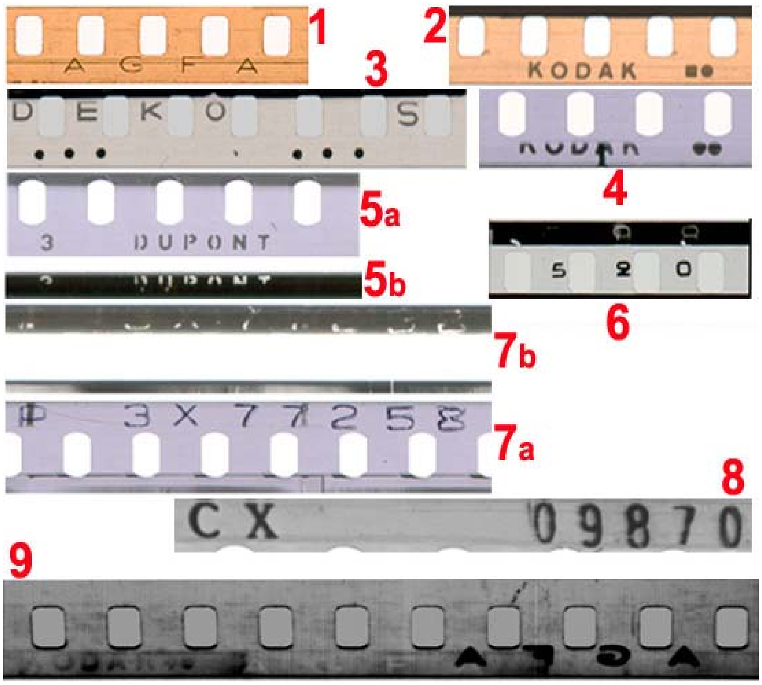
When the marks are reproduced, a photographic reversal takes place, and the marks are then comprised of transparent marks on an opaque background.

Following this simple rule, any "transparent" mark on stock other than reversal cannot pertain to that stock[135]. And if the mark in question is on a negative, it will be placed on that stock in at least the third generation.

Studying the marks which appear (added or reproduced) on each stock can provide a great deal of information as to the past history of the stock and of the film.

The endless variety of situations which can be detected by means of studying these marks makes it impossible to comment upon them at any length. For illustrative purposes, one of the possibilities this type of analysis has to provide is provided.

- As their name indicates, the footage marks will always be located spaced a foot apart from one another (every 16 or 40 frames, depending on whether 35mm or 16mm films are used).
- To the contrary, the manufacturer's, type of emulsion marks, etc. may be spaced differently (every 19, 21, 40 frames), but, on one same roll, two marks of exactly the same type will always be spaced the same distance apart.
- During stock inspection, the equal spacing between marks can be an exact tool for assessing the amount of stock lost in each break or splice, but, additionally, when the marks of the negative or of intermediate duplicates are found on certain stock, this may also be a highly valuable tool for determining the stock's generation-related status.



F. 139
Edge marks and generations of duplication
[1-2-3] Edge marks in prints. [4] Edge mark in a negative. [5a] Edge mark in a negative duplicate reproduced in [5b] a positive. [6] Print Agfa-Gevaert with its own mark between the perforations and part of footage number of a negative.
[7a] Footage number impressed in a negative duplicate Kodak.
[7b] The same numeration reproduced in a print.
[8] Footage number photographically introduced (latent image) in an negative Ilford. [9] Agfa print with its own mark and the marks reproduced from a positive duplicate Kodak and an negative Agfa.

Although marks from all of the previous generations will generally show up reproduced on the edges of films, they may also not be reproduced.

135 With the exception, once again, of reversal stock.

- When the reproduction has been made in optical printer or in printers which do not reproduce the edges or which reproduce solely the edge marks on one edge.

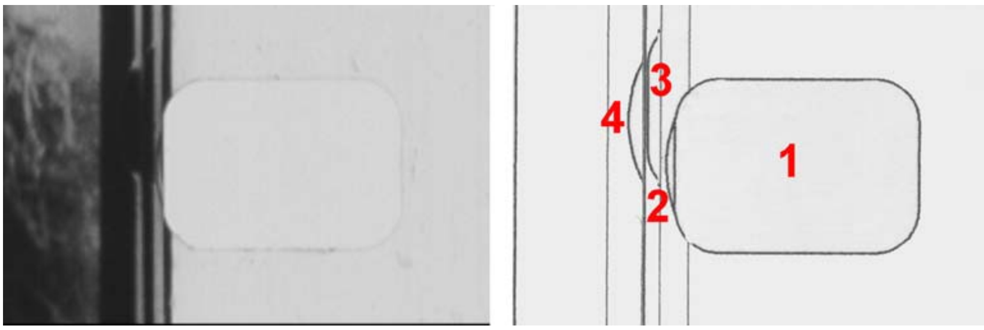
F. 140
Negative duplicate obtained in an optical printer.

- When the marks added to the stock proper in latent image are completely fogged by the printer edge reproduction light.

Figura 141 - Edge marks reproduced by fog
The "simple" rules can fail when we are talking about complex realities. The footage number impressed in this negative material, was accidentally reproduced on the same material by happening a small fog (which has not affected the image) during the handling of the reel. In the image we can observe the number [4OY G89445] and reproduced the other [4OY G89446].

- When there are digital sound tracks located on the edges.
- When the originals used for the reproduction do not have edge marks, which is a frequent situation although no manufacturer makes mention of it.

The analysis of the perforations that figure in the following illustration, belonging to a movie of 1939, allowed to determine that was a print of fourth generation and that the high granninnes came from having been used, as positive of second generation, a standard print, obtained for the presentation to censorship of the movie.



F. 142
[1] Perforation of the print.
[2] Perforation of the negative duplicate.
[3] Perforation of the print used as positive duplicate.
[4] Perforation of the negative.

The negative assemblers and other laboratory technicians usually add marks to the edges of the films or to the framelines between frames or anywhere else on the support that is not going to be seen on the screen.

- The assemblers may write the number for each shot in indelible ink and even, in silent films, assessments regarding the quality of the take.

F. 143
Inscriptions outside of the image area in a silent negative. Reproduced from a print, they identify this negative as the negative “4” of the film, shot 313, change of light 460.
(Image prepared by Luciano Berriatúa)

- In some eras, marks have been added to pinpoint the position of the dissolves.
- Also for many years, the grading change marks have been made using physical marks on the film edges.

F. 144
Three grading cuts, in a sixth generation material belonging to a documentary film, made during the cutting.

All of these marks (which may be difficult or impossible to interpret) may make it possible to assess, on sound bases, the continuity or the quality of a certain stock and the study of the light values with which the premiere reproductions were made

4.121.2 - Damage

Damage is always unique. There is no chance of two different pieces of stock sustaining exactly the same damage to one same frame.

Damage to stock can then be irrefutable proof of its relationship with the other stock on which that same damage is reproduced. At the same time, the fact of certain stock (i.e. a negative) showing damage that is not reproduced on copies which have been made from that stock will afford the possibility of dating (at least relatively) the reproduction of said copies.

From these standpoints, the marks added by assemblers and laboratory technicians have the same effects as damage.

If using damage as a means of determining the generation-related status of a reproduction, one must consider:

-The characteristics of the damage
- Its effects on the side of the film on which it is located
- Its behaviour during reproduction

By combining these three criteria, guidelines can be set which will make it possible to study damage to determine the generation-related status of the stock in question.

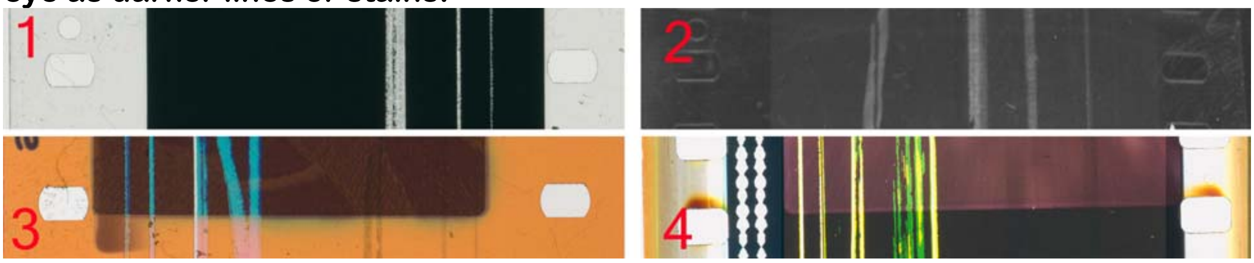
Damage, even the most minor or that which is not seen as being damage (such as the edge of a perforation or that of a splice on a negative[136]), always entails a loss of transparency on the stock and will therefore be noticeable in the form of more or less opaque areas on the support where this damage has been done and will show up as more or less transparent on the reproductions.

This damage being noticed as more transparent or opaque areas will also depend upon the transparency and opaqueness-related characteristics of the image photographed in the damaged area and of the side of the film on which the damage in question has been sustained.

In keeping with their behaviour in reproduction, there are three basic types of damage:

- Scratches and other damage which give rise to emulsion detachment
- Stains, marks and fogging which cause opaqueness
- Breaks, splices and perforations which lead to a loss of support

The scratches on the non-emulsioned side (glossy side) are seen with the naked eye as darker lines or stains.



F. 145: Scratches

Black and white frame scratched on both sides: [1] Image by transparency. [2] Image by reflection. The leaning scratch, made on the shine side stays totally oversahdowed by the photographic density.

[3] [4] Layers of emulsion in negative and colour positive.

On B/W stock, the scratches caused on the emulsion will be noted as more transparent or more opaque lines, depending upon the photographic density of the damaged emulsion.

On colour stock, the transparency/opaqueness factor is further complicated by the structure of the layers of these emulsions.

Depending upon how deep a scratch is, it may have affected solely the protective gelatine layer or, alternatively, one or more of the three colour layers.

- In the former of these two cases, slightly opaque lines will be visible, and slightly transparent lines will be reproduced.
- In the latter of these two cases, this will depend upon the arrangement of the layers of the emulsion.

If the damage was caused to a negative or duplicate type emulsion with a standard layer arrangement (yellow, magenta, cyan); if the damage affects the

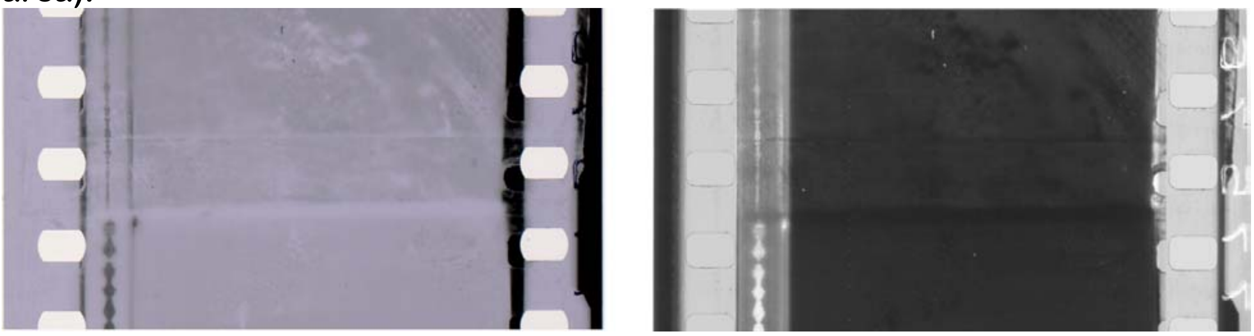
136 The perforations and the cuts in the splices are made by shearing, which means the transparency of the plastic being destoryed on the cutting line.

yellow layer, the magenta and cyan layers will be left, and the scratch will be seen as blue by the naked eye and will be reproduced as yellow; if it affects the yellow and magenta layers, it will be seen as cyan and will be reproduced as red.

If the damage was caused to an Eastmancolor copy type film with the emulsion arrangement transposed (magenta, cyan and yellow); if the damage affects the magenta layer, it will be seen as green by the naked eye and will be reproduced as magenta; if it affects the magenta and cyan layers, it will be seen as yellow and will be reproduced as blue.

In any event, the intensity and the tone with which the damage is seen by the naked eye and is reproduced will depend upon the density of the colour in the unaffected layers and, naturally, if the damage affects all three layers, it will be seen as transparent and will be reproduced as opaque.

Stains are always reproduced in the form of heightened density (darkness), and some types of stains may be much more noticeable on the reproduction than on the original (i.e. an acetone stain, located on the support in a transparent image area).

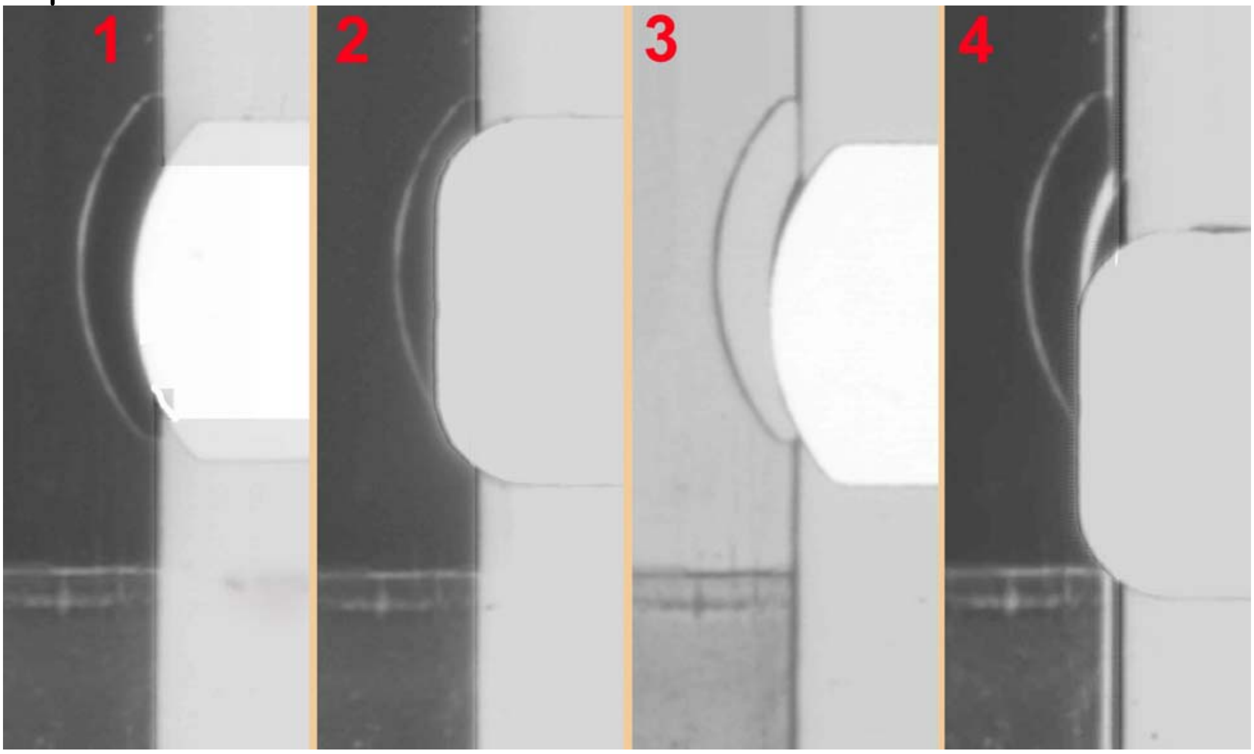


F. 146 - Reproduced splices and stains
Upper, a duplicate negative obtained from a nitrate copy which presented a splice rustic and bent. The edges of the splices and the stains of the solvent used appear as transparent shadows. The duplicate also shows small opaque stains taht reproduce damages of the original print emulsion.
In the copy obtained from this duplicate, the transparent shadows changed into opaque, having the same aspect of the original nitrate. The small opaque stains changed again into transparent stains.

As perforations and splices are elements which are found on predetermined models, the characteristics with which they are seen by the naked eye and are reproduced, combined with those inherent to the negative or positive films which are being inspected, will make it possible to determine in all certainty whether they were made on a negative or on a positive.

- On the film on which a perforation has been made, the edge of the perforation will be opaque. On the reproduction, the edge will be a transparent line, whilst the area of the perforation will show up reproduced at maximum density.
- For a cement splice, made by overlapping the two tails of the film, the edges of both films will be opaque lines, whilst the contact surfaces will be denser than the adjacent frames. On the reproduction, the situation reverses, and the spliced area is reproduced as a lighter area bounded by two transparent lines.

Thus, in the reproductions of perforations or splices, an opaque-edged line will indicate that the perforation or the splice in question was made on a negative or positive film similar to that which is being inspected, whilst the border lines will be transparent if the film was of the opposite type to that which is being inspected.



F. 147 - Reproduced perforations

[1] [2] Positive duplicate and print from the original negative: Transparent edge of the perforation of the negative; opaque edge of the perforation of the material. [3] Third generation, negative duplicate: Opaque edge of the perforation of the original negative; opaque stamp of the perfored of the negative duplicate; opaque edge of the perforation of the material. [4] Fourth generation, print: transparent edge of the perforation of the original negative; transparent stamp of the perfored of the negative duplicate; opaque stamp of the perfored of the positive duplicate; opaque edge of the perforation of the material.

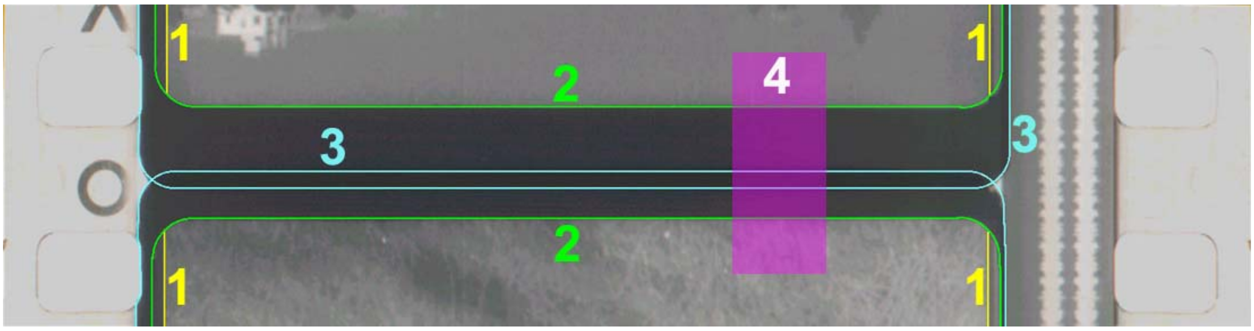
Paying attention to the Negative→Positive / Transparent→Opaque transition throughout its infinite variations is the most reliable tool possible for determining the generation-related status of every piece of stock reproduced throughout a motion picture's past history.

4.122 - Reproduced Gates, Settings and Perforations

As has been mentioned in previous sections of this document, the dimensions of the camera gates and the frame setting position took many years to be standardised, and the standards regarding gates have not been well respected. In practice, each manufacturer builds its own camera gates as it sees fit, and different gates can even frequently be found in cameras of one same model. And what has been said about the camera gates is also true with regard to the printers used in reproduction.

Along general lines, there admittedly being many different variations, the contact and alternate feed printer gates, the continuous feed and the optical printers are of different characteristics which are detectable in the reproductions.

- For the alternate feed (step by step) feed optical printers, the gates are of the same shape and proportions as the silent film or sound formats of the image negatives, although they may be of slightly larger dimensions.
- The same is true for the contact and alternate feed machines. These machines also have openings for allowing the reproduction of the edge marks located on the film.
- The edge marks are also reproduced in the continuous feed printers, but these machines cannot be said to have true gates, but rather slots past which the entire film runs.



F. 148 - Reproduced frames
[1] Lateral edge of the printergate. [2] Side of the step printer (maybe an optical printer) used for the obtention of the positive duplicate. [3] Printergate of the step printer, used for the obtention of the duplicate negative. [4] The final print was obtained in a continuous feed printer which did not change the frameline.

The combination of the differences in shape and size of the gates, the frame setting position and the differences in the equipment used in reproduction can be a reliable guide for detecting the generation-related status of the reproductions and a unique source for ascertaining the past history of each motion picture and of its reconstruction and restoration.

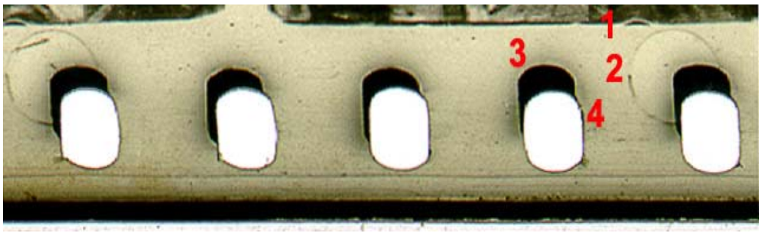
When dealing with determining which stock is a camera original and which is a reproduction, the sole existence of elements reproduced outside of the image area (outside of the frame) takes on major importance.

With the sole exception of the marks added by the manufacturers, there cannot be any image outside of the frame area on any reversal positive or negative camera stock. The existence of any reproduced mark can be used to classify the stock as a "reproduction".

Nevertheless, in complex processes, there is no set rule. Sometimes, by accident or due to the deterioration of the stock, marks may appear which may be subject to being interpreted as the result of reproduction.

When one is working on new stock reproduced in perfectly well-tuned machines, the perforations of the original stock should not show up reproduced on the copies, but when the originals are shrunk or when the equipment is not well-tuned, the edges of the perforations will be reproduced on each consecutive generation, and these reproduction defects can be another aid for generation-related identification purposes.
Regarding silent films prior to the standardisation of perforations, the information stemming from the analysis of these elements will provide reliable

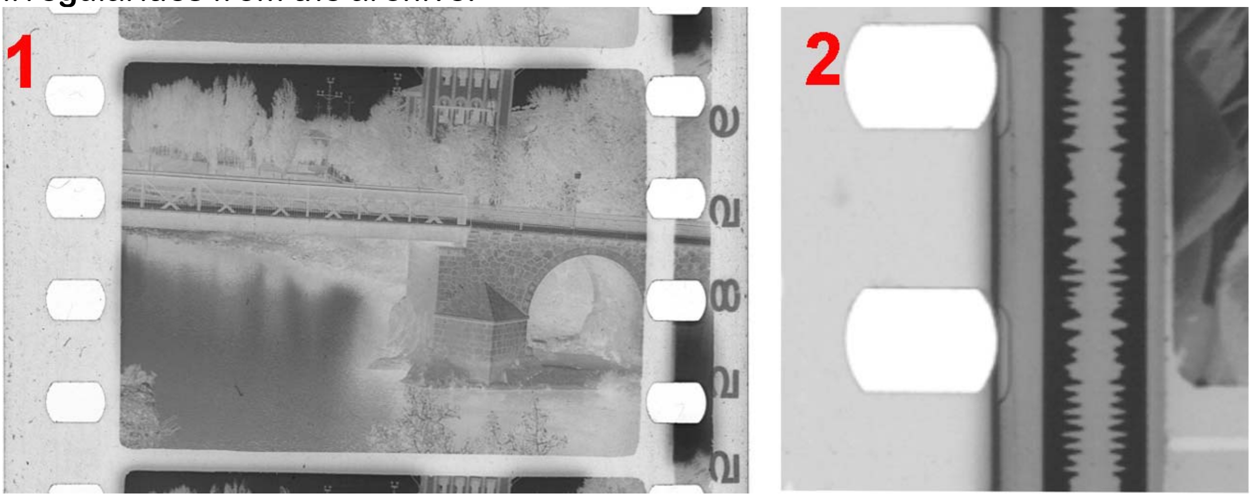
data regarding the past history of the stock and can therefore serve as a guide for identifying and cataloguing these films.



F. 149
[1][2] Negative & print with perforation Lumière; in the print the perforation appears complete, which to obtain the third generation [3] was used a device that maintained both movies in contact. [4] Fourth generation print.

It can be said all of the manufacturers had accepted the established standardisations by around 1930. As of that point in time, there being two types of perforations on 35mm films can contribute to facilitating the analysis of the generation-related status of the stock and, sometimes, to the assessment of the quality of the reproductions and of the film proper.

Nevertheless, when reading these marks, it is always necessary to bear in mind that the duplication process is extremely complex and, can be made in adverse circumstances with the wrong equipment, which may introduce unverifiable irregularities from the archive.



F. 150
[1] The camera negative presents a part of image filmed between perforations. [2] The reproduced perforations don not come from a print used in the duplication process, but from the sound negative reproduced in a wrong aligned printer.

4.2 - Materials Created During Motion Picture Production

In the process of making a motion picture, in conjunction with the original negatives, the duplicates for conservation and reproduction and the release copies, many other materials are created which, despite their being of no monetary value once they have fulfilled their intended use, may contain documentary elements of major cultural interest and may sometimes be fundamental to collecting further data regarding, to reconstructing and to restoring many films.

The structure and function of many materials undergo changes during the production process. Therefore, when studying this stock from the archive-related standpoint, it is advantageous to pay attention to the final characteristics of each stock, describing it exactly as it may be received by the archive.

Apart from this, in the work of classifying stock, knowing and being able to determine the function for which each stock was created is a basic activity which is necessary for correctly determining the intrinsic value of the stock in question and its possible importance for the preservation of the motion picture to which it is related.

4.21 - Shooting Materials

Although it may seem paradoxical, the original negatives never make it off the shoot.

A large part, most or even all of the stock that will go into making an original image or sound negative may have been filmed or recorded during the film shooting process, but until this stock can be made into original negatives from which it will be possible to make the release copies, it will have to be cut, assembled and further processed using techniques and other stock which were not involved in the film shooting process.

The camera negatives and the live sound recordings comprise the stock produced during the film shooting process. [137]

4.211 - Camera Negatives

The camera negative, that is, the film on which the image was filmed, can also be referred to as the "as-shot negative" and is one type of stock which has changed least throughout filmmaking history.

The major changes made in camera negatives have to do with:

- The technical possibilities of the equipment
- The use of emulsions for duplication
- The length of the rolls the cameras will take

To preserve photographic quality, during most of the silent film era and, to a lesser extent, also during the beginning years of the three-layer colour emulsions, a large part of the image effects - the fade-outs to black or white and the superimposed dissolves - were done directly using the camera by closing and opening the shutter until the image dissolved completely as a result of underexposure or overexposure or by backwinding the film and then re-filming to superimpose the image.

These techniques would cease being used for shooting films with the advent of the duplication emulsions, which would make it possible to create the image effects in the laboratories, more conveniently and reliably preserving the quality of the results.

Camera rolls progressively grew longer in length throughout the entire silent film era, from 15m - 30m of film which the first cameras would take, up to the 1000 feet (305m) filmstrips would measure during the silent film to sound film transition period.

Nevertheless (a good camera is a very expensive piece of equipment), 30m, 60m and 120m rolls have continued being used, mainly in the lightweight cameras used for shoots with no live sound.

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137 In these sections, for purposes of simplifying the explanation provided, the variations introduced by the existence of reversal stock are not discussed.

An "as-shot" negative is a readily-identifiable type of stock.

- **It is normal to find several takes of one same shot one after the other, which (in professional jobs) will start off with the image of the clapperboard showing the data necessary for distinguishing each individual take.**
- **At the beginning and end of each take, there are usually fogged areas and other "cut" marks added to mark the end of the take.**
- **On a roll of camera negative, all of the footage is numbered in consecutive numerical order.**

The negatives are filmed to be cut and assembled, and the possibility of complete rolls of "as-shot" camera negatives making their way to the archives has almost always been relatively very slim throughout filmmaking history. The advent of electronic image technologies - first for television and ultimately industry-wide - has changed this situation.

Television archives conserve many TV productions filmed on photochemical supports which were edited and broadcast in electronic image systems. The television archives likewise have thousands of tapes of original video recordings from newsreels which are conserved exactly as received by the archive.

In the filmmaking industry in general, the current possibilities of making high-quality digital reproductions from photochemical negatives and of doing all of the editing and the effects on these reproductions, making a new, fully edited photochemical negative from them have led to the negatives filmed during the shooting process being left, increasingly more often, in their original "as-shot" condition.

4.212 - Sound Recordings

If camera negatives have undergone relatively few changes, the exact opposite is true for live sound recordings.

For many years, optical sound systems were the only ones which could be used for recording live sound during shooting. The continuity and overall characteristics of these "as-shot sound negatives" are similar to those of the image negatives.

As of the advent of sound films, as a result of the problems involved in shooting both image and sound combined, as the camera moved somewhat, studio dubbing very soon became a widespread practice, and live sound negative recordings were used only for those shots that included dialogue for which synchronisation was a crucial factor.

The identification of "as-shot" live sound negatives is based on the same elements as the image negative, including the fogging and cut markings indicated for those types of stock.

Starting as of the advent of sound, the slate image is included along with the reading of the shot, the take and the clapper number, the recording of which is perfectly visible on the image as well as being heard in the sound.

The use of magnetic stock began with unperforated tapes, used for recording documentary elements (i.e. speeches) in which the synchronisation problems were of lesser importance that the use of the original sound.

The advent of perforated magnetic films and of systems equipped with synchronisation devices for unperforated tapes (such as the pilot signal on the "Nagra" tape recorders) eliminated optical sound systems from shoots, magnetic supports then being used as live recording stock

4.22 - Image Editing and Sound Processing Stock [138]

Editing techniques began almost immediately after the birth of filmmaking. and can be grouped into three well-defined eras:

- The silent film era
- Sound editing on photochemical supports
- Electronic editing

Except for the beginning years of filmmaking and the first attempts at sound editing perhaps, the editing process is thought out and made first on reproductions and, solely once all of the decisions have been made, on the negatives.

Splicing using self-adhesive tape is a common element which is very typical both on image cutting copies and on synchronised sound production tracks. In fact, it can be said that self-adhesive tape first made its way into the filmmaking industry to be used on this stock.

4.221 - Cutting Copies

The cutting copy is the most typical image editing stock. In many countries, this copy is put together from the dailies or rushes made for checking the quality of the filmed material.

The cutting copy is comprised solely of images and is the copy on which the synchronisation and dubbing of the film are co-ordinated, as well as the position and developing of the image effects, this copy ultimately serving as a guideline for the cutting and assembling of the negative in the laboratory.

The cutting copy is a fundamental material during the motion picture production stage, and the recovery and study of cutting copies by archives can afford the possibility of ascertaining many of the particulars involved in the filmmaking process. However, by the time cutting copies have served their intended purpose, they are damaged, spliced and marked throughout and can hardly be used to recover a motion picture.

4.222 - Electronic Edition

Around 1988, a new editing technology started becoming popular. This technology had been developed based on video techniques and on the adding of latent image barcode edge marks providing the possibility of automatically reading the roll footage.

In AVID editing technology, the camera negative is reproduced on a video support on which the footage codes are recorded.

The editing process is thought out, planned and done completely on computers from the reproductions in video or on the computer's own hard disks,

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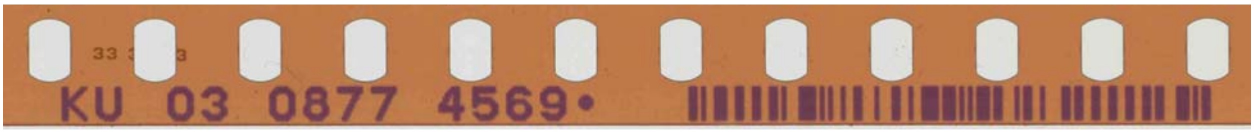
138 Given that these sections are devoted to describing the stock exactly as it is received by an archive, the negative and copy editing processes are discussed in Sections 4.24 and 4.26.

and the editing systems generate precise instructions for the cutting and assembling of the original negative.



F. 151 - Footage codes and bar codes in edge marks of a film Kodak.

In digital technologies, the camera negatives can be transferred to data files and, once the editing is done on video recordings (on the systems mentioned in the preceding paragraph above), the electronic editing is done on the data files, and it is possible to reproduce these files to obtain a completely finished negative .

This set of systems has led to the cutting copy having completely ceased to exist and has created new materials which archives may be receiving as editing stock, that is, the "as-shot" video master recordings, the video copy edited during the editing process, the data recording tapes reproduced from the camera negatives and the master data tapes edited for obtaining the photochemical negative.[139]

4.223 - Synchronised Tracks

Sound editing techniques would start developing when systems and equipment were invented which would make it possible to reproduce and mix the optical sound recordings made on shoots and in studios. The advent of perforated magnetic films would make it possible to further advance along this path of development, improving the quality of the results. The advent of digital editing systems has totally revolutionised the realm of sound editing in the filmmaking industry.

The traditional sound editing process starts by reproducing the "good" sound recordings made on the shoot or in the studio on supports which can be handled using the same equipment on which the image editing will be done.

These reproductions are used to put together a new set of materials, the synchronised tracks, on which each sound element will be laid out in proper order in keeping with the image editing.

Although more types of tracks are sometimes used, the dialogues, music and effects are the types most often used.

Each synchronised track is edited into the same number of cutting copy rolls, keeping those sound recordings which were made individually separate from one another.

- Not every one of the tracks may exist for those rolls of the cutting copy on which no sound elements of the type corresponding to that track are included.

139 In these films, the fully edited video or data master will contain the entire motion picture and, even when the negative were to be reproduced, they should be considered as being the authentic "First full original stock of the film".
The negatives made by means of digital kinescopying are usually referred to as "intermediate digital" negatives, due to this type of emulsion being the one used for making these negatives.

- When sounds of the same types which have be recorded separately must be reproduced in conjunction with one another, the sound for each one of the sound sources is edited into a separate roll. Therefore, for one roll of the cutting copy, several rolls may be made of a certain synchronised track.
- To keep in sync with the cutting copy, each roll of the synchronised tracks starts synchronised with the "start" of that roll on the cutting copy. As there may be areas without any sound ("voids") on each roll, what is often done, in order to prevent extraneous noise from being included and to cut costs, is to insert pieces of discarded or non-emulsioned film into the footage wherever these "voids" are found.
- Although all the rolls of the tracks must start up from the cutting copy "start", each roll may end when the sounds recorded on it come to an end, this being why one may come across rolls of tracks which are shorter (even much shorter) than the cutting copy roll.

4.224 - Mixed Tracks

On the synchronous tracks, each sound element is provided along with the loudness values suitable for making it intelligible to the greatest extent possible.

During the editing process, when the synchronised tracks are being put together, the synchronisation between sounds and images is analysed and decided upon, but the sound values of each one of the recordings comprising the tracks will continue to be dealt with separately.

The combined sound among all of the tracks which must be reproduced simultaneously will be produced in the final mixes, during which each sound element will be dealt with according to its importance, modulating its loudness (presence) and other characteristics according to the overall needs of the motion picture as a whole.

Generally speaking (although there are many variations), three types of mix tracks are usually produced:

- Three individual tracks (music, effects and dialogues).

It is very common for the three individual tracks or the international track and the dialogues to be reproduced, roll by roll, on one same magnetic support.

- International track (music + dialogues).

When preparing the mix tracks for the versions dubbed in other languages, the dialogue track prepared for each language and the separate music and effects tracks or the international track is used.

- Mixed track

The mix track includes all of the sound elements, assessed according to the needs of the motion picture. It is the sound original of the motion picture, from which the sound negative will be made.

4.23 - Image Effects, Leaders and Titles

Although there are numerous variations, these three types of image elements have a unique relationship with the negative:

- They are filmed and produced on separate stock.
- They are incorporated by way of reproductions or are solely incorporated into the film in the copies.
- The originals filmed for this stock are usually conserved and can be recovered separate from the original negative.

4.231 - Silent Film Titles

F. 152
Title filmed for the positive cutting of the english version of a spanish production.

Although the making up of the titles (credits) by the negative→positive technique was a relatively common technique throughout the early years and at the end of the silent film era, the most popular technique for producing these materials (and the leaders) consisted of filming them directly with the characteristics corresponding to the positive copy.

The fact of the titles having been filmed as positives and having been edited directly into the copies has led to the possibility of recovering rolls of credits which were not even edited into the copies or which were cut and replaced by other signs made up with the distributor's marks or in other languages.

With the advent of sound films, the explanatory titles would stop being used in films within a very few years.

4.232 - Leaders and Image Effects

During the silent film era, the leaders were made working along the same lines for titles. After emulsions for duplication became widely used, three different approaches have been taken for making up leaders:

- When they are comprised solely of texts on a black background or on a still image, they are usually filmed and incorporated directly into the negative.
- When the texts are superimposed on moving images, they are produced using the image effect techniques and are incorporated into the negative as reproductions.
- The leaders prepared for the distribution in versions dubbed into other languages can be incorporated into the negative duplicates from which these copies will be made, or can be kept on separate rolls along with the original negative stock to be assembled into the copies by splicing.

Image effects started being put together in laboratories as of the point in time at which the existence of suitable emulsions made it possible to produce them by means of reproduction without any loss of quality. Nevertheless, the necessary techniques would take some time to be developed, and in the 1930's it was still possible to find effects produced directly on the camera negative.

4.24 - Original Negatives

In photochemical filmmaking, bearing in mind that original negatives are comprised of the original recordings or of reproductions, it can be said that there have four different types of original negatives throughout their history:

- In the first three types, the original image negative is basically comprised of the camera negatives filmed during shooting.

- Throughout most of the silent film era, in most productions, the image negative did not include the full length of the film and was made up almost completely of camera negatives.
- In the second type, which was that of the end of the silent film era and the beginning of sound films, the image negatives changed to be the full length of the film and to include some reproduced elements (effects).
In this second type, when the sound negatives were incorporated, these negatives would also be comprised of the original recordings made during shooting or in the sound studio.
- In the third type, which is still being used today and which has been used throughout almost the entire history of sound filmmaking, the image negative (with some exceptions) continues to be comprised basically of the camera stock, but the sound negative is now stock obtained by means of reproductions.
- In the fourth type, which has cropped up several times throughout motion picture history and which is currently undergoing further development, the image negative has also changed over to being made up completely of reproductions.

4.241 - Original Image Negatives

Silent film era negative editing characteristics differed completely from those which would be developed for sound filmmaking; nevertheless, the original image negatives have some characteristics in common.

On the original negatives, the shots used to be assembled by means of splices.

Solely those shots included in certain image effects produced in the laboratory (superimpositions and dissolve fade-ins/fade-outs) may have photographed splices.

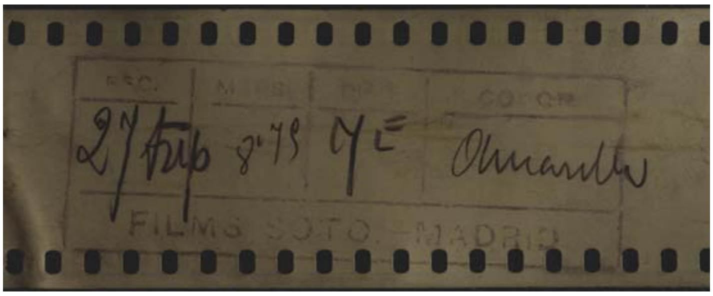
The footage numbering come from the camera negative and on the original negatives are not in order other than within each individual shot.

Since motion pictures began to become longer, it then became possible for several different cameras to be used on a shoot. Therefore, several different types of gates can be found on the original camera negatives.

F. 153a - Three formats of camera in the same movie.

4.241.1 - Original Negatives from the Silent Film Era

The limitations imposed by the reproduction equipment, the technique used for adding colour to the copies and the need of achieving the suitable resolution on leaders and titles led to negative editing being done in a system which (with an endless number of variables) can be considered to be organised into two steps:
- The "editing sections" comprised the basic grouping (the first step) in editing a silent film negative.



F. 153b
Insert in a negative with: the number and the length of the shot, the grading and the tint.

Each editing section consisted of shots which had to be reproduced under the same or similar exposure conditions on stock of the exact same colour treatment.

The sections were numbered in keeping with the order which would be determined in the final editing of the copies, this numbering frequently being found marked on the first frame of the section or on a white tail piece inserted between two section for this purpose. In many cases, along with this numbering, indications can be found regarding the exposure necessary for the reproduction or the colour corresponding to the section in question.

The position of leaders and titles were indicated by inserting some frames of the corresponding text or a piece of film (white tail or fogged film) on which the numbers of the title or a few words to identify it were written. Sometimes, this indication could be as brief as a single mark which would be interpreted by the editor.

F. 153c - Insert in a negative with: movie title, numbers of parts, shot and title, tint and length of the shot.

- In the second step of editing, the negative, the negative was prepared in rolls of the length suited to the load limitations of the laboratory machine.[140]

Each one of the rolls ("blocks") prepared for the reproduction process might include several editing sections or, to the contrary, an editing section longer than what the machinery would take could be divided into several blocks.

In the reproduction blocks, the sections retained their numbering whilst the block per se might not have its own numberings but however bear indications as to the reproduction and colour characteristics.

140 The length of the "reproduction blocks" depended upon the characteristics of the frames available for developing and drying at each laboratory. With some differences, due to the laboratory equipment, "blocks" less than 60 meters in length were very frequent up until the mid 1920's.

Very often, concepts such as "part", "day" and similar may appear on the copies, concepts which have nothing to do with the negative editing and sometimes not even with the editing of the copies either.

4.241.2 - Sound Film Original Image Negatives
The characteristics of talking picture negatives were initially set back around 1935 and, involving some variations which would depend upon the technical development achieved by each filmmaking industry, these characteristics remained unchanged up to the advent of digital technologies.

The classic negative editing scheme for sound filmmaking was developed in two stages:

- In the first "negative cutting" (which can be done immediately after its processing), the camera rolls are divided up into each one of the takes recorded on them, organising each take into separate rolls marked with the numbering of their footage and the take and shot number.
- The second stage (negative editing) is done following the indications included on the cutting copy and on the editing lists. During this stage, the stock of the selected takes is spliced to the exact continuity and lengths, along with the effects and leaders made in the laboratory.

Sound filmmaking stabilised a concept of "roll" or "part" which would continue to be used for many years for editing negatives.

The roll length would measure around 300 meters, which is the length the rolls of film for copies were being supplied around 1930. All of the laboratory and projection equipment was adapted to work at least on this length, which would continue to be the theoretical standard, even after film manufacturers changed over to marketing copy and duplication stock in much larger rolls.[141]

In some films during the transition from silent films to talking pictures or with the advent of the first triple-layer emulsions for colour, the negatives of the effects prepared for making the overprints directly on the copy stock can be found. These negatives may be conserved incorporated into or separate from the rest of the image stock. In both cases, the image (and sound) negative roll structure has been modified to allow for the reproduction of combined copies.

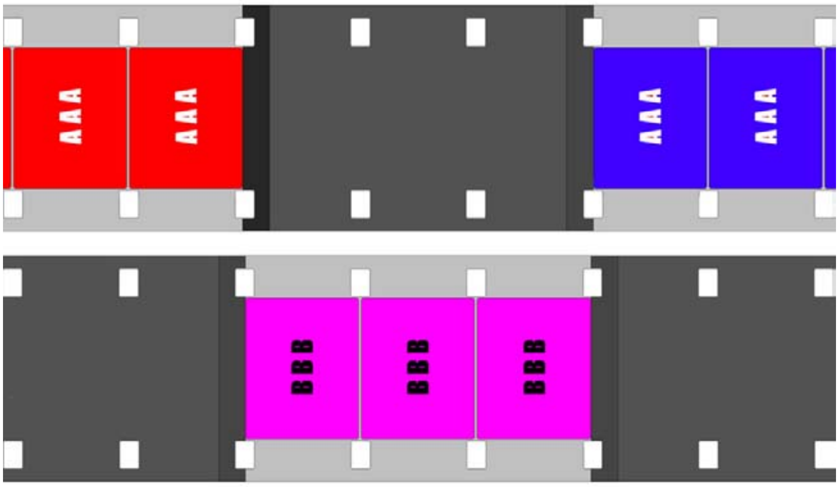
Another technique was also used, mainly for the overprinting of the leader texts, which modifies the structure of the negatives. The negative of the texts is superimposed and joined at the head on the image negative. This situation, known as "sandwiching", affords the possibility of making direct overprints but gives rise to many different conservation-related problems.

For the 16mm negatives, a technique was developed aimed at preventing the splices from showing up on the screen. In this technique, known as "A" and "B" cutting, which has also been used in motion pictures filmed in "scope" formats, each roll of negative is split, dividing the consecutive shots into two cut reels (the uneven-numbered shots on one and even-numbered shots on the other) and inserting a completely opaque continuity tail piece of exactly the same number

141 Although it is a commonly-known concept, the 300-meter roll (1000 feet) is a theoretical measurement and, up until the 1970's, the rolls of negative ranged around 100-400 meters in length.

of frames as the shot edited into the other reel in between each "good" shot on a reel.

In reproduction, each roll of copy must be exposed one after the other under the two negatives.



"A" – "B" Cutting

4.241.3 - Reproduced Image Originals

For some films, the stock available for making the copies has no element obtained directly during shooting recorded on it. This is the case, for example, of the colour matrixes of Technicolor films (both of those filmed using the three negative system as well as when a triple-layer camera negative was used) or of the original 35mm negatives of those filmed in Super 16mm.

Starting as of 1995, due to the advent of digital technologies in the field of photochemical filmmaking, this type of original negatives which contain no elements filmed during shooting is becoming more popular. Digital reproduction technologies make it possible to digitally make internegatives from electronic image supports.

In this technique, the original recordings which may have been made on photochemical supports or directly on digital video systems are transferred to a suitable digital format in which all of the stock selection and film editing processes are done. Once the editing process has been completed (in which the original recordings will not be used again), the film is kinescoped in negative on photochemical supports which, for all intents and purposes, will be the "original image negative".

Naturally, the Technicolor matrixes, the dupe negatives made by blowing up the Super 16 negatives or the intermediate negatives of the digital kinescoping have no splices nor any of the other aforementioned characteristics of discontinuity in the footage or changes in the gates.

4.242 - Original Sound Negatives

During the early years, until equipment was invented which would make it possible to mix several different sound sources, sound editing was done similarly to image editing by putting the optical sound recordings made live during the shooting or in the sound studio together with the proper degree of continuity to form the sound original. Naturally, the sound takes do not have to be of the same length as the image takes.

In order to prevent bloops caused by splices on the sound negative, a system was developed which has continued to be used whenever splices must be made in sound negatives or in combined reproductions.

The silencer element consists of a perforation (generally triangular in shape) which takes up the entire width of the track and which is reproduced in the form of an opaque triangle on the copies. These silencers are highly effective and cut the bloop caused by the splices down to the point of making it inaudible.[142]

F. 155
Triangle for noise reduction in the sound negative, reproduced in a print.

Another distinguishing characteristic of the initial beginnings of sound negatives is the editing, on one negative, of sound takes made using equipment from different systems, used, for example, in the studio and for exteriors.

During this same era, it was also common to insert pieces of transparent film into the sound negatives in order to cover those sections which had no sound elements.

4.243 - Reproduced Original Sound Negatives

The possibility of mixing several different sound sources to make a new sound negative meant original sound negatives would be reproduced stock and, following along behind the development of the equipment which would make it possible to mix recordings made separately to make a new optical sound negative, sound negatives consolidated the characteristics which they have continued to have up to the advent of digital systems.

As a product of a reproduction, each roll of original sound negative must be comprised of one single unspliced piece of stock

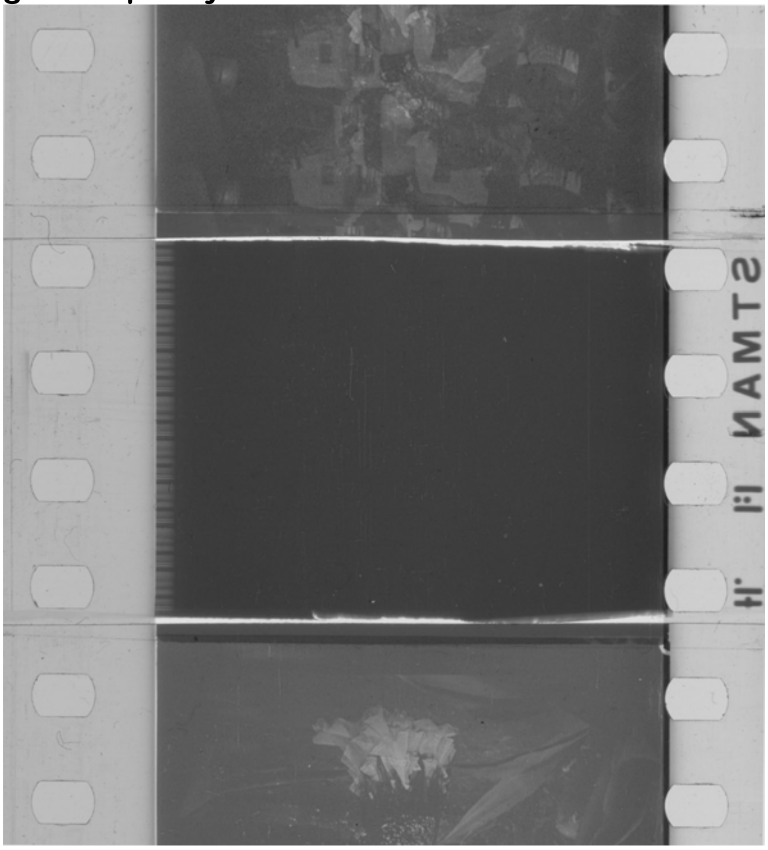
When a splice is found during the technical inspection of an original sound negative, the reason for this splice must be investigated in order to determine whether it is due to duplicates or editing done in the laboratory or is due to accidental breaks.

Laboratory splices can be due to the length of the roll editing of the image negative which were to exceed the 1000 feet, which raw stock rolls usually measured when supplied, or sometimes due to the need of minor synchronisation adjustments being made after having reproduced the sound negative.

For these synchronisation adjustments, some frames can be eliminated, or a piece of transparent film (one or two frames in length) inserted in the original

142 On the copies, in order to cover the noise of the splice, the silence is added by way of a patch of opaque stock adhered to the track or by drawing a triangle in indeleble ink.

negative, which will be reproduced as an opaque image on the copies and may go acceptably unnoticed when shown on the screen.



F. 156
Frame spliced to a picture negative to correct the synchronization.

The involvement of censors and distributors may also be conducive to the making of cuts and splices on sound negatives.
In any event, the splices made in the laboratory will be 'blooped' by a cut in a triangular shape.

The synchronisation between the image rolls and the sound rolls is marked on the protective tails/leaders located at the start and end of each roll. But, on negatives which have changed laboratories or which have been reproduced in several copiers, several synchronisation marks may appear on each roll.

4.25 - Positive and Negative Duplicates
Duplication stock is a reproduction and, therefore must have no splices between shots, and the footage numbering must be in consecutive numerical order within each one of the rolls.

Just as has been mentioned for sound negatives, when a splice is found during a technical inspection, the reason for this splice must be investigated.

Laboratory splices may be due to duplicates made for the purpose of achieving the proper quality or due to the flaws in the condition of the original used in the reproduction.

The length of the rolls can also lead to splicing being done. Up until the manufacturers started supplying duplication film in 600m rolls (and until the laboratories adapted their equipment to copying these lengths), when the original used was over 300m in length, the duplicate was reproduced in two separate sections which were later spliced together.

This technique is currently still being used to reproduce originals conserved on 300m rolls and to edit the duplicates on double rolls, as well as to form 300m or 600m rolls of 16mm duplicates blown down from 35mm films.

The existence of laboratory splicing means that the duplication was done in several individual processes; and, generally, this could be detected by observing the continuity of the footage and the reproduction characteristics on the edges.

When a splice is due to duplicates or reproductions made from separate originals, the existence of different numbering sequences can be detected, or (when one same roll of film has been used for a duplicate), several feet of film will be missing.

If the discontinuity of footage caused by the splice is only two or three frames, this is a undoubtedly a matter of an accidental break in the duplicate proper.

The characteristics of the reproduction may also provide some valuable indications. One single shot (or set of shots) which are especially damaged on the original may have been reproduced in another type of printer or by reversing the loading position of the original, these being circumstances which can mark differences in the gate shape and size, in the reproduction characteristics on the film edges and in the relative positioning of the image reproduced and of the edge marks on the duplication film.

Naturally, and this is often the case due to the actions taken through the involvement of censors and distributors, a duplicate may have been cut eliminating part or all or one or more shots. These types of actions cannot be detected during the technical inspection without the aid of the cataloguing data.

Except in those countries (actually, in the vast majority) in which, due to their marketing possibilities, the exporting of films is not common, the widespread use of duplicates led to the negative originals used for making release copies being negative duplicates.

In motion pictures filmed in black and white, combined duplicates containing image and sound are often found. This type of stock does not exist (or should not exist) in colour films.

4.26 - Release Copies

The original negative can be interpreted and reproduced many different ways and, many times, the copies available at the archives are not the result of original reproductions made under the direct control of the producers of the motion picture in question, but rather have been reproduced at any later point in time and may not retain the values of the original photography.

A positive copy from the original reproduction which retains at least part of its photographic characteristics is the only reliable source of information regarding the type of reproductions which the producers of each motion picture were aiming to achieve.

The archives must try to conserve the copies from the original premiere release reproduction of the motion pictures. Regardless of the condition of these copies, or of whether they are falling to pieces, or that solely some rolls are left, or even if the colour has completely faded. The corresponding light, colour and continuity values are on the original screening copies or can perhaps be deduced from them.

F. 157
Frame of two prints reproduced with different intensities of light.

As has repeatedly been mentioned, the relationship between the negatives and the release copies has changed throughout motion picture history.

In most of the motion pictures from the silent film era, the final editing was done on the copies to be released for showing on the screen, which greatly facilitated the making of changes on the part of the producers or distributors, who could change the titles in order to include their own trade name, or to adapt them to other censorship situations or commercial conveniences.

Silent films could be shown with colours totally different from those selected for the premiere showing or with changes in the editing made to shorten or lengthen the length of the film to accentuate the importance of the elements which had met with the greatest success or simply to replace damaged negatives.

In practice, during the technical inspection of silent film stock, above all when the stock is from different distribution areas or from reproductions made during different eras, one must always consider the possibility of major differences existing between each new stock located and those already known to exist or conserved from that same motion picture.

In sound films, the relationship between negatives and copies has been much more stable.

The most remarkable changes have to do with the length of the rolls of film which the projectors take and with the length of the rolls of raw stock supplied by the manufacturers. For many a year, negatives and copies were edited, reproduced and shown on theoretically 300m rolls. Later, the copies changed over to be edited and shown on double rolls (theoretically 600 meters) and, lastly, projectors changed to be able take the load of an entire motion picture and, sometimes, to allow one same copy to be shown simultaneously and consecutively in several theatres, even without the need of re-threading the projectors. Each one of these changes has left its own mark on motion pictures.

When single or double rolls are shown, the starts and ends of each roll are the parts damaged most, this being what would lead to the common practice of the rolls - in the original editing - being started and ended with fade-outs or scenes in which continuity was not crucial.[143]

The projection systems that afford the possibility of editing complete motion pictures has lessened yet not completely done away with damage to the ends of the rolls, but have given rise to other types of damage (due to pulling or twisting) due to the characteristics of how the film runs through the projectors used.

This type of damage can be readily detected on all copies and is very noticeable on those copies which have been used a great deal. When reconstructing/restoring a motion picture from its release copies, the differences between copies used as single or double rolls can be of major importance[144].

4.27 - Cuts, Discards and Unused Working Materials

The stock which may come into archives include many pieces of stock which were discarded or not used during the final editing process or in the distribution of the motion picture.

Much of this stock will be not be worth conserving at all, but they may sometimes provide valuable information related to the history of the motion picture or the era or country in which it was produced.

Carefully studying this stock (above all, when they are from fiction films) can be an impossible task for those archives which do not have a large number of technicians on staff, but familiarising oneself with them is necessary in order to determine whether they must be conserved (waiting for a chance to be able to study them) or can be thrown away.

143 This practice is due to the differences in length which, based on the theoretical 300 meters, are constantly encountered. To lessen the impact caused by the inevitable damage at the start and end of each roll, editors attempted to locate the roll changes at points which would allow for a certain degree of loss of continuity, which naturally worked against unifying the length of the rolls.

144 See TEXTUAL NOTE XI

With the exceptions discussed in Section 4.211, the "as-shot" rolls of camera negative is not stock which usually comes into archives all in one piece.

In conventional technology, the camera negative is cut and prepared for assembly by separating each one of the takes on the rolls. The good takes are selected, and some of them will be cut and assembled on the original negative. Throughout this process, stock will progressively show up which can be sent to the archives:

- First, the takes which have been found to be no good
- Next, the shots and takes which are good, but which are not included in the editing of the negative
- And last of all, the pieces discarded (clippings and tails) of the takes included in the assembling of the film.

In fiction films, how this stock is valued will depend upon the circumstances surrounding the shooting of the film and can solely be determined in collaboration with the cataloguing department. But, in documentaries and, above all, in newsfilms, this whole set of stock may contain as much or even more documentary information than the sections selected and included to assembly the film.

From the standpoint of their possible documentary value, the cutting copies used for checking the film which are made from these negatives are just as important.

On the original negatives, by means of the re-editing done by the producers and the cuts ordered by the censors or by the distributors, stock is taken out of the film which may make its way to the archives.

The stock taken out of a finished negative unquestionably belonged to the film and, in principle, if they were to be recovered, should be put back into the film.

But, in each case, the archives will have to decide as to whether these materials should be incorporated into the film or should be conserved separately. The cultural archives have to consider the full conservation of the film and its historical circumstances, which includes the changes it has undergone during public showings.

Making this type of decisions is not an easy matter, and no one single valid criterion can be applied to all cases.

4.3 - Versions and Variations

Accepting the existence of an "original version" which would contain the original image stock with texts or dialogues in a certain language means accepting the fact that, in filmmaking, many different nuances come into play but, at the same time, also means accepting the fact that other versions may exist which must be classified as "non-originals".

In principle, when one thinks of "non-original" versions, one usually thinks of versions in which the texts or dialogues are in languages other than the language in which the motion picture was originally filmed, but there are many types of versions which are distinguished from one another and defined based on aspects which having nothing at all to do with language.

There are versions which incorporate or leave out shots or whole scenes, which use different image stock for the same scenes, which are edited differently using the same image stock, or which have made changes in the texts or in the dialogues to a much greater extent than that which is involved in a change in the language.

And it must also be accepted that certain technical modifications, such as a change in image system or in emulsion or in gauge or format, lead to substantial variations in the image and sound reproduction characteristics, these being characteristics comprising the very essence of the filmmaking vernacular.

Due to the characteristics proper of the audio-visual industry and due to the existing differences among the different social and cultural realms in which motion pictures are shown, stock may come into the archives from the same motion picture with substantial differences which must be classified as different versions of the same motion picture.

As was stated at the beginning of this section, stock can be classified by an archive solely if those in charge of cataloguing and of the technical inspection work closely with one another, and for the classification and evaluation of the versions and variations there may be among materials, this collaboration is especially important.

4.31 - Versions Prepared During Production

With the exception of home movies and productions for specific sectors in particular (educational, scientific, industrial, military, etc.), which, from the filmmaking standpoint, can be considered to be semi-professional, motion pictures are produced to be shown on the most widespread basis possible, and this need of having them shown as far and wide as possible can lead to the several versions of one same film being produced at the same time or one after the other.

4.311 - Different Images

Up until the time at which emulsions for duplication were used on a widespread basis (1925-1935), several negatives were commonly made of each take in productions of any importance, and it was necessary to ensure that there would be copies of good photographic quality in the different distribution areas.

The negatives could be filmed simultaneously, using two or three cameras, or by way of one repetition after the other of the same take. Sometimes, due to the needs of the market in question or because of damage to the original negative, it was necessary to resort to the use of takes which has previously been discarded due to quality-related problems.[145]

Although on not such a widespread basis (due to the relatively slow rate at which emulsions for colour began being used industry-wide and due to Technicolor being used for making copies), the advent of colour emulsions would once again make it necessary to produce several camera negatives, up to the advent (1952-1956) of triple-layer emulsions with integral masking suitable for the negative and positive duplication of the camera originals.

145 This topic has been researched in depth by Luciano Berriatúa. See: *"Los proverbios chinos de F.W. Murnau"*. The Spanish Film Archive. Madrid, 1990 and the documentary "*Los cinco Faustos de Murnau*", produced by Filmoteca Espanola in 1998.

4.312 - Images in Different Languages

Throughout the first few years after sound films first started being made, prior to the time when sound track editing and duplication techniques had been developed, quite a few motion pictures were produced in which (at least those scenes which had dialogue) each shot was filmed in each one of the languages in which the motion picture was going to be marketed.

The filming for each individual language was done one after the other and could be performed by the same or different actors. For different reasons, mainly in motion pictures co-produced among studios in different countries, this practice would continue up to the 1940's.

Censorship and the need of marketing the motion picture in countries where different degrees of permissiveness were allowed would lead to filming specific scenes for one version and to shooting one same scene several times with different elements (i.e. wardrobe) for each version. [146]

4.313 - Editing Differences

The variations discussed in the sections above entail several editing processes, but there are also many types of actions which are taken exclusively during the editing process.

During the silent film era, for most films, editing the negatives was considered as being "organisation for duplication" in which the needs due to the limitations of the rduplication equipment, of the systems for adding colour to the copies and of achieving the proper resolution on leaders and titles were met. As has previously been said, these editing systems left the way open to modifications of all types being made.

Due to the fact that sound editing depends upon the synchronisation of the sound and image negatives, there were fewer possibilities of changes being made, but due to censorship or to marketing-related needs, changes have continued being made in the editing process, shortening or cutting out compromising scenes or "cutting down" the length of the motion pictures.
The changes which have taken place in the distribution systems have led to new "formats" of hit films being produced in which scenes which had previously been cut out are included or are "touched up" and the images with which the moviegoing public is already familiar are revamped in keeping with the current tastes or technical possibilities at the time. [147]

The reconstructions made at the archives during the restoration process can also be considered to be new versions of the films.

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146 Two sets of unused negatives pertaining to the same film were recovered once by Filmoteca Espanola. The stock was labeled with the words "summer" and "winter". Naturally, people wear fewer clothes in summer than in winter, and that was exactly the difference between the negatives of the two versions that had been edited for the motion picutre in question.

147 The marketing techniques developed for motion picture advertising on television have made the use of these types of "uncut", "restored" or "redone" versions profitable, which are sometimes advertised as "the original version" or "the director's edition", providing the necessary argument in favour of launching them on the market again.

4.314 - Sound Track Modifications

During the transition period from silent to sound films (1927-1932), many silent films were also shown as sound films, generally including only musical elements and retaining all or a large part of the titles. In some cases, sound was added to films produced quite some years earlier and, in some countries, this practice continued for many years, bringing out "new versions" without titles and with sound added in the form of narration and dubbed dialogues.

In the co-productions produced by studios in countries where different languages are spoken, original versions are usually prepared for each one of the languages, and each one of these versions will simultaneously be both a different version and the original version.

During the shooting of this type of co-productions, each actor may sometimes speak in his/her own language, which leads to there being no unified "original version".

Until the time when stereo sound was used on a widespread basis in theatres, for those films produced using stereo systems, monaural sound tracks could be prepared for showing films in all types of theatres. These sound tracks are obviously versions differing from the original used for the premiere release.

4.32 - Versions Prepared for Distribution

To facilitate the dissemination of the films throughout all realms of the audio-visual market, in addition to dubbing the dialogues into languages other that the original one, many types of changes can be made which must be considered as being different versions.

4.321 - Changes Made in the Dialogue

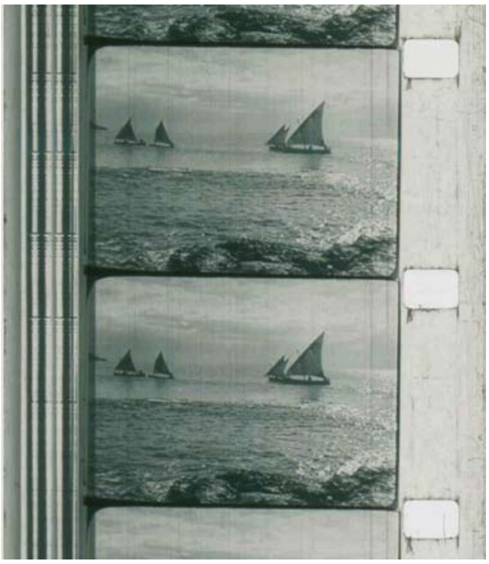
As has been mentioned in previous sections of this document, in silent films, the distributors frequently put together the titles for the copies that were shown in their own area. Changes which could be confined to making up new cards with the same texts, but including the distributor's trade name or the text translated into other languages, but which could also make changes in the text, adapting them to the censorship standards in effect at the time or changing the names of the leading characters or even the way in which the plot developed.

Sound films would standardise three systems for the preparation of versions in other languages, which included the preparation of a new mix track with the dialogue in the language of the country where the film was going to be distributed; the inserting of the dialogue in text (subtitles) located on the frame and, in documentaries, the inserting of a narration superimposed on the original narration.

4.322 - Modifications in Technical Features

Reproducing films on supports, formats or emulsions other than the original for distributing the films on secondary circuits is common practice in the filmmaking industry. If one bears in mind the importance of these changes in the characteristics of the image, they must be said to be true version variations.

All of the motion pictures filmed in 70mm, in the five-perforations format, have also been show in 35mm scope copies[148]. Films shot in 35mm have been shown in 16mm, as well as in 9.5mm, 8mm and S8mm.



F. 158
16mm print of a professional 35mm film.

Films shot in silent format have been reproduced (correctly or damaging the image beyond repair) on sound formats, and films shot in scope have been shown in flat formats.

For many years, film for colour was much more expensive than film for black and white, which led to B/W copies being made of many films made in colour.[149]

The copies on videotapes and DVD discs are a clear-cut case of these types of variations, not solely due to the change in the technical means, but due to the changes in format and sound track which these reproductions usually entail.

148 Even films in three-screen Cinerama have been reproduced on one single "scope" support.
149 During that era, the workprints were made in many countries using black and white stock. Starting as of 1990, the comparative pricing of color and black and white film reversed, and the working materials for films shot in black and white have now changed over to being made on color emulsions.

5 - Preparing Film Classification Tables [150]

In order to make data retrieval, statistical analysis and the organisation of the collections possible, it seems necessary to set up databases and to enter the results of the inspection of the stock (the data) using tables which will group and define its characteristics and condition.

It is extremely important to bear in mind that introducing the results of the inspection using tables will always be slower than jotting results down by hand, but the direct objective of the databases is not to facilitate the data entry process, but rather to make it possible to retrieve this information.

It is not possible to set up a system of tables, no matter how broad-ranging one may wish to make them, that will take in all of the many widely-varying situations which may come to bear with regard to the stock which is received by the archives. The almost endless variety of stock will always be a source of some surprises and will lead to dealing with certain unforeseeable situations.

Apart from this, there are certain items of data which cannot be entered using tables, and some information (such as that related to the condition of the stock) can solely be explained accurately by writing out the opinion of the technician who makes the inspection.

In addition to the "technical" data describing the characteristics and condition of the stock, the table must take in the administrative data regarding the reception and legal situation of the stock in the archive in addition to the identifying filmmaking historical and technical data concerning each film.

The tables which are set out below solely take in part of the experiences of one single film archive, and other film archives will naturally have to work based on other experiences which may be completely different.

To facilitate data retrieval and the making of statistical studies for classification purposes, the set-up proposed for these tables is based on the criterion of filling in one single field in each table. This criterion makes it necessary to make many simplifications and, in some tables, makes it necessary to use "Notes" or "Remarks" field to a great extent.

5.1 - Background Data for Stock Inspection

This first set of tables deals with collecting the administrative data concerning the source of the stock - the data warranting the stock having been received by the archive - and the basic data necessary to maintain each stock identified "on an individual basis" up to its classification and final cataloguing.

5.11 - Administrative Stock Reception Data

Each archive must proceed in accordance with the actual situation in which it is working. Nevertheless, there are some minor elements of judgement which, in

150 This section is based on the study made by the Spanish Film Archive for developint the stock classification stables in the database created for monitoring its film collection. Also see TEXTUAL NOTE XII.

one way or another, due to the benefits that involve the assessment of the stock and for planning the acquisition policy, must be followed by all archives.

The documentation which accompanies the film when it is received by the archive may be of crucial importance for identifying and evaluating the stock in question.

The receiving orders and delivery notes issued by laboratories, film studios or distributors may provide some very important data (such as the copy number on the laboratory duplication order) or make it possible to identify the original stock or machines used for the duplication.

In many cases, this documentation is not formally handed over by those in charge of the film being delivered to the archive, but rather these are documents which simple "come with" the film. There may be labels on the packages or on the containers of each roll, or they can be distributor checklists or possibly censor documents, etc.

The importance which all of these different types of information may have, cannot be determined prior to inspection, and whenever possible, all of the documents accompanying the delivery of the film, must be passed on to the technician who is making the inspection so that he/she may use them in evaluating the film.

When film comes into an archive, solely the data necessary for determining its source and to identify each film, is collected.

5.111 - Source

The identification of the person, company or organisation from whom the film in question has come, the reception number and other similar data are items of information which the archives cover according to the needs of their administrative organisation, it being obvious that, for an archive which has a very close relationship with the industry, these items of data may be highly useful for the historical analysis of their stock.

Of all this data, the date of receipt is especially important. Many materials are accumulated at an archive over many years' time and, for example, to determine which copy may be from the reproductions produced for the premiere showing, having the exact date on which each stock came into the archive on file can provide the most reliable information.

TABLE 01 - SOURCE TYPE

01 - Unformalized deposit

Applicable to stock the donators or depositors of which do not need to sign the documentation inherent to the assignment or deposit of a property.

02 - Private deposit

A deposit regulated under the regulations in force in each individual country for those deposits made voluntarily by private citizens or by companies.

03 - Institutional deposit

For those archives which are depositories of the motion picture patrimony of a community (country, region, municipality), the deposits made mandatorily by public organisations, companies or private citizens in terms of the rules of law which do so determine.

04 - Purchase

05 - Purchase from laboratory
06- Own reproduction

The existence of these three entries is based on the need of distinguishing among the film which was purchased once printed, that which was commissioned directly by the archive to be printed and that which was printed at the archive's own facilities.

07 - Exchange

At some archives, it is also mandatory to mark the stock that is delivered as a balancing item which is deleted from the archive.

08 - Unknown

A classification the many uses of which are well know to all archivists.

09 - Temporary loan

The processes applicable to this stock, which is received for use for showing or reproduction, can be defined as revision or state checking and will always be different from those which are applicable to the stock to be archived and may be defined as review and condition check.

5.112 - Identification

At the measure-taking level - prior to the inspection - at which the arrival of the stock to be archived is situated, all of the identifying data must be considered as being tentative and subject to further verification.

For administrative reasons, even when they are corrected, these tentative identifications must always be kept attached to the history of the stock.

Title Upon Receipt

When stock comes into the archive, it may not have a title at all or may bear an incorrect title. In the first of these two cases, the stock will have to be assigned a title, although this may be done simply by resorting to name it using the name of the depositor and the receipt order number. In the second case, when the documentation accompanying the stock received (or on the containers) shows a title, the title in question must be accepted for the receipt of the stock, even when, due to presuming that it is incorrect, remarks are added indicating the possible error.

Reference

Sometimes, for example, when several copies of the same motion picture come in, the receipt title and the identification of its source may not suffice to individualise each film. In these cases, some characteristic which will complete its identification can be used. For example, in the case that has been mentioned, the number of the copy could be included.

Stock Type

At a further point in this document, a table is included for the "Stock Type" concept, but at point in time at which the stock is received, it seems preferable to record this item of data exactly as provided by the owner, depositor or seller making the delivery. The industry often uses its own technical terms (which would not be included in the tables) which may provide information of importance.

Number of parts, containers or rolls

5.12 - Basic Film Cataloguing Data

One of the main objectives of the technical inspection is that of checking to ensure that the original technical data of the film and those of the stock which is to be studied tally.

Therefore, when the databases the archive uses so allow and when the stock which is to be inspected pertains to a film already catalogued, the technician making the inspection of the new stock should have direct access to the basic filmmaking historical and technical identification data, and to the length/duration of the film in question when it premiered.

Filmmaking history Identification

The minimum data necessary for identifying a motion picture is generally considered to be: Title, Studio or Production Company, Director and Year produced. Nevertheless, the cataloguing department is the one which must determine what these items of data are to be and how they are to be verified during the inspection.

Support Type

The fact that the basic stock of the films was produced on flammable or safety supports is undoubtedly an important item of data for evaluating the stock which is going to be inspected.

Image System

The advent of electronic image technologies and of the procedures for transfer between these two image systems makes it necessary to know which system was originally used for showing the film.

Colour/Sound Relationship

The existence of colour systems with black and white negatives or of sound film negatives shot using full-aperture cameras, as well as many types of reproductions incorrectly made makes it necessary for the technician making the inspection to know whether the films was a silent or sound film and whether or not it was shot and shown in black and white or in colour or with coloured copies or mixing scenes (or rolls) in colour and black and white.

Gauge, Recording System and Projection Format

The reproductions made using changes in gauge and/or format (correctly or incorrectly done) and in analogue recordings on digital systems are totally frequent in the filmmaking industry.

Length / Duration

This item can be given in either of these two values.

It will also be useful to know the number of rolls in the original editing and, for silent films, the filming and projection speeds for the main premieres.

5.13 - Film's Condition of Preservation

It is necessary to know whatever data the cataloguing department may have regarding the condition of the films subject to becoming part of the basic archive assets.

The condition can be typified by way of a relatively very simple table:

TABLE 02 - FILM CONDITION OF PRESERVATION

01 - Not found

02 - Originals damaged or destroyed

03 - Preserved incomplete or on stock other than original stock

In these three situations, any stock located may be important for the conservation or restoration of the film.

04 - Preserved on stock not inspected by the archive

A transitory situation for films whose originals or basic conservation stock has been located, but there is not sufficient information regarding their characteristics and condition.

05 - Film preserved on being located and inspected

5.14 - Identification of the Material Used as Original for the Reproduction

Determining this item of data exactly can be a routine, simply administrative task or can be totally impossible.

When reproductions inspected directly by the archive or which have come from studios, distributors or laboratories with which the archive has relations are involved, this data can be pinpointed from the stock delivery documentation proper.

For old stock and for that reproduced in situations unknown by the archive, determining what the original used was may require employing all of the technique for identifying the generation of the reproductions and the conducting of specific research into the history of the film.

When, by means of the inspection process, it is not possible to determine the original stock and the date on which the reproduction was done in all certainty, all of the data obtained must be set out, indicating the sources referred to.

5.2 - Relationship of the Stock with the Motion Picture

The following two sets of tables deal with the complex classification of the relationship between the film and images and sound existing on the stock inspected.

The fact of the stock recovered being complete or incomplete, in good or poor condition, has no bearing on these classifications.

5.21 - Relationship with the Motion Picture

Accepting that "the motion picture" is the film precisely as it was finished and exactly as it was premiered by its producers or distributors, in any of its versions, a table can be set out affording the possibility of classifying the stock pertaining to the motion picture and to those created for its production or promotion.

TABLE 03 - RELATIONSHIP WITH THE MOTION PICTURE

01-Motion Picture Stock

Original negatives, duplicates or copies of the film exactly as it was finished in any of its versions.

02- Version Inserts

Stock produced for making the copies of certain versions which are conserved separately for replacing or complementing those existing on the original negatives or on the markings duplicated.

03- Production, Distribution or Censor Cuts

The situations in which, due to the involvement of the censor or of producers or distributors may make changes in the motion pictures which are too great to deal with. The stock cut by way of the measures taken by those listed above can solely be considered as pertaining to the motion picture when they have been made on the finished picture.

04- Image Negative Production Stock

"As-shot" negatives and cutting copies, discards and shots not used, as well as the original filming carried out for the preparation of leaders and effects.

05- Sound Negative Production Stock

Original recordings and synchronised tracks and mixes on optical or magnetic supports.

06- Promotion Productions

Trailers, Promos, "The Making Of" and other stock prepared for the motion picture ad launching.

07- Casting and Other Miscellaneous Shots

Casting shots, location shots, etc.

5.22 - Versions and Variations

Based on the acceptance of the existence of an "original versions" which would contain the original image stock edited or synchronised with texts or dialogue in certain languages and with some other editing, gauge, projection format characteristics, as well as a certain relationship with colour.

5.221 - Versions

These sets of tables are aimed at classifying the versions prepared for distribution in other linguistic areas or under other socio-political circumstances. The changes made in the finished work by producers, directors or distributors or by elements unrelated to the film, such as the censors and the measures taken for reconstructing/restoring the films.

TABLE 04 - VERSION CLASSIFICATION

01- Original Version

All of those produced and premiered by the producer or co-producers of the motion picture, in the language(s) of their respective countries.

02- Double Version - Export Version

For firms shot and edited (at least in part) on several negatives, the versions other than the version original considered as original.

For silent films, all of the stock from different distribution areas must be considered, in principle, as possible different versions.

For films produced on photochemical supports, the editing done for television viewing (i.e. in mini-series format) can be considered as such.

03- "As-Shot" Version

Films in which the actors speak in different languages and which were premiered dubbed, unifying the language.

04- Director's Version - Uncensored Version

Originals or reproductions which conserve all of the original footage pertaining a films in which the editing or the original dialogues were modified after having been finished prior to their having been premiered due to the imposition of the film studio or of the censor's office.

05- Dubbed, Subtitled or Superimposed Narration Version

The sound track or title in languages other than the original language or with overprinted subtitles or superimposed narrations.

06- Revival with New Dubbing
When new dubbing or subtitling is done or when parts not previously translated or cut out by the distributors or by the censors are incorporated.
07- Revival with New Editing
Re-editing done by the producers or proprietors for the revival of the film, although they are billed as "restorations".
08- Sound Versions of Silent Films
Produced for the commercial dissemination of the motion picture.
09- Restored Version
When the reconstruction/reproduction produced entails the copies having to be made from a new negative stock (image and/or sound stock), reproduced from stock reconstructed using systems suitable for overcoming the damage sustained by the originals of the motion picture in question.

TABLE 05 - LANGUAGE VARIATION CLASSIFICATION
This table complements the preceding table.
01- Language of Original Version
The fact that the characters appearing in the film speak different languages has no bearing on the definition of the language considered as being that of the original version.
02- Dubbed Version
Language in which the dialogue and/or leaders and, in silent films, the leaders and titles.
03- Subtitled
04- Superimposed narration
In these two cases, the original language and the language in which the subtitled or the narration are filmed must be indicated.
05- Shot in Several Languages
For films in which the actors spoke in several languages but which were dubbed and unified for the premiere showing, the stock which conserve the dialogue recording on the shoot.
06- Silent Without Intertitles
Both the silent stock which no longer has any titles as well as the stock of the films which never had any titles at all.
07- Several Versions
Stock with optical and magnetic sound tracks in a different language or electronic image supports with several sound tracks. In both cases, all the languages existing in the stock would have to be indicated.

5.222 - Technical Variations
Considering that the original characteristics of each film are the same as the photographic and sound characteristics obtained with the original supports and emulsions, all those reproductions made on stock substantially different from those of the filming and/or commercial premiere of the film in question are classified as different variations.

This set of table is an attempt at classifying the editing done during production for showing the film in a different medium and the reproductions produced using systems, gauges and formats other than those used for shooting and the original distribution, when these variations modify the technical characteristics of the motion picture in question.

TABLE 06 - MEDIUM VARIATIONS
For films which have been structured in different editions for showing them at movie theatres or on television
01- Movie theatre edition
02- TV edition
03- DVD and Video tapes versions
This kind of editions only are considered as variations of a version when it includes sound tracks or subtitles in various languages and/or bonuses, like "Making of", or inserting scenes not edited in the edition for showing.

TABLE 07 - GAUGE CHANGE VARIATIONS
Reductions
01- 35mm reproduced from 70mm
02- 16mm reproduced from 35mm
03- 8mm, S8mm or 9.5mm reproduced from 35mm or 16mm
04- Systems of several supports in 35mm reproduced on one single 70mm or 35mm support
Blow-ups
05- 70mm reproduced from 35mm
06- 35mm reproduced from 16mm
07- 9.5mm or 8mm reproduced in 16mm or 35mm

TABLE 08 - CHANGE OF EMULSION OR SYSTEM VARIATIONS
01- B/W from Colour original
02- Colour from B/W original
03- Kinescoped from electronic original
04- Telecine process from photochemical original

TABLE 08 - FORMAT CHANGE VARIATIONS
On photochemical supports
01- Academy format made by reduction from silent format
02- Silent format reproduced by clipping the image located below the sound area
03- Flat panoramic format from Scope
On video media
04- Scope at 4:3 (full screen)
05- Panoramic at 4:3
06- Scope or panoramic to panoramic simulation on 4:3 screen
07- Scope to panoramic simulation on 16:9 screen
08- Panoramic to panoramic simulation on 16/9 screen

5.3 - Stock Type & Technical Characteristics

5.31 - Image System

The "Image System" concept refers here to that which is used for recording or reproducing the stock inspected, which may naturally be different from the original of the film. Magnetic sound stock also comes under this heading.

TABLE 09 - IMAGE SYSTEM
01- Photochemical

Photochemical image and/or sound films (although they be from the kinescoping of electronic image stock) and magnetic perforated sound films. Perforated magnetic sound films are to be inspection in conjunction with the photochemical ones, although they are going to be archived separately.

02- Electronic 625-line

03- Electronic 525-line

Tapes or rigid image and/or sound supports from films produced in electronic image or obtained by means of telecine transferring photochemical films.

5.32 - Material Type

In keeping with the use for which the stock was created, they can be grouped into two classifications: basic stock - originals, duplicates and release copies - and working stock.

In the model given in this table, each type of stock is dealt with separately. Another criterion exists, widely-used and efective, which considers that they must be classified along with all of the stock which must be used together, as, for example, the image negatives and sound negatives.

TABLE 10 - MATERIALS TYPE CLASSIFICATION

Original stock

01- Image negative

02- Image negative in "A" and "B"

Image negative comprised of several sets of stock which must be combined with one another in the reproductions

03- Colour separation image negative

04- Negatives of inserts, headers, subtitles and direct overprints

Stock which must be used with the rest of the negative for making copies in certain versions or for the making overlays.

05- Sound negative

06- Double Track or 1.75 sound negative

This classification is necessary because, although these types are simple sound negatives, their characteristics condition the stock's use and conservation.

07-Reversal positive

08-Reversal positive with Com-Mag sound

The sound tracking may have been done before or after the filming, which has repercussions on the edition of the material.

In material filmed for television, the sound of these tracks may have been used only as direct sound register or reference sound.

09-Sep-Mag sound on perforated magnetic supports

This classification would solely apply to the sounds synchronised to a reversal positive such as, for example, for television newscast stock.

10-Original video master

The video master concept can be applied to many types of stock. Under this classification, it is suggested for the original recordings or the reproductions which are the original stock for a certain edition of a motion picture filmed or reproduced in video.

Duplicates

11- Positive image duplicate
12- Positive duplicate of colour separations
13- Positive combined image and sound duplicate
14- Positive sound duplication copies
15- Negative image duplicate
16- Negative combined image and sound duplicate
17- Negative sound duplicate
18- Technicolor matrixes

Access and Use Copies

19- Standard copy
Copy including image and sound (Combined copy)

20- Standard Silent copy
Concept apparently contradictory but necessary when referring to silent film release copies which are totally finished for showing (even if the inspected material only is a fragment of the print).

21- Reversal copy
22- Reversal copy with Com-Mag sound.
23- Access video copy

Working Copies

24- Image check copies (dailies)
25- Cutting copy
26- Combined work copy
On classifying the stock of this type, it is a good idea to specify the use for which they were created.

27- "Zero" copy, First standard copy

Tracks

28- Mix track
29- International track
30- Effects tracks
31- Music tracks
32- Dialogue tracks
33- Magnetic sound cut from optical
34- Sound recordings on smooth magnetic supports

Miscellaneous, Discarded and Unused Stock

35- Original header and overprint stock
36- Negative, discarded, unused and cut stock
37- Positive discarded, unused and cut stock
38- Unedited original video stock

Discs

39- Magnetic or magnetic-optical disc
40- Optical disc
41- Gramophone record

Supplementary stock

42- Check strips of changes and grading.

5.33 - Support, Gauge and Format Classification

TABLE 11 - SUPPORT

Films

01-Nitrate

When nitrate and acetate parts are combined on one same roll or these two plastics are divided into different rolls or the roll is classified as nitrate.

02-Diacetate
03-Butyrate or propionate acetates
04-Triacetate
05-Polyester
Discs
06- Metal
07- PVC
08- Polycarbonate

TABLE 12 - GAUGE

Although they are different concepts, the gauge of the perforated image films and sound films, the width of the unperforated sound tapes and the recording format of the digital video and audio systems can be grouped together in one same table.

Gauge of photochemical and perforated magnetic films
01-35mm
02-35mm , 2-perf
03-16mm with two rows of perforations
04- 16mm with one row of perforations
05- 65mm
06- 70mm
07-9.5mm
08- 8mm
09- S8mm
10- 28mm
11- 17'5mm
12- Others
Sound on unperforated magnetic tapes
13- 2" tapes
14- 1" tapes
15- Open 6.25mm tapes
16- 6.25mm cassettes
17- DAT cassettes
18- Others
Electronic image formats
19- 2" Quadruplex
20- 1"B
21- 1"C
22- U-matic LB
23- U-matic HB
24- U-matic SP
25- Betacam
26- Betacam SP
27- Betacam Digital
28-D1
29- D2
30- D3

31-V8
32- Dvcam
33- Dvpro
34-Vídeo 2000
35- BetaMax
36- VHS
37-SuperVHS
38- HI8
39- Others

TABLE 13 - PERFORATIONS
Only on 35mm-gauge stock
The long and short gauge variations are not considered.
01- BH copy
02- KS negative
03- Scope (Fox-Hole)
04- Dubray-Howell DH
Pre-standard silent film era perforations
05- Round
06- Edison rectangular type
07- Pathé rectangular type
08- Other types

TABLE 14 - PROJECTION FORMATS
Despite its having to do with the projection format, this classification is also taken into account for negative and duplicate stock which is not intended for showing on the screen.
35mm formats
01- Silent 1:1'33
02- Academy 1:1'37
03- Panoramic 1:1'66
04- Panoramic 1:1'75
05- Panoramic 1:1'85
06- Scope
07- CinemaScope 4-track
08- Others (VistaVision, Cinerama, 3D, etc.)
Formats in other gauges
09- 16mm
10- Super 16mm
11- 16mm panoramic
12-70mm 5-perf
13- Other 70 mm formats (Imax, Omnimax, etc.)
Video stock screen proportions
15- 4/3
16- 16/9

5.34 - Emulsion and Sound System Classification
The following two classifications are complementary.

TABLE 15 - EMULSION TYPE

This is a debatable classification. There are numerous examples of films incorrectly duplicated (including in negatives) on copies or reversal emulsions used to give a negative.

01- Negative
02- Positive
03- Magnetic
04- Optical recording or stamping

TABLE 16 - COLOUR SYSTEM
For electronic images, this classification would be that of the colour system.
- Emulsions for black and white
01- Black and White
02- Black and White with hand colouring or stencilling
03- Black and White w/dyes
04- Black and White w/ toners
05- Black and White w/stencils and dyes
06- Black and White w/dyes and toners
- Films with B/W emulsion for projection or reproduction in colour
07- Additive systems for projection using filters
Negatives or copies
08- Subtractive B/W systems for Colour
Negatives, duplicates or Technicolor matrices, Cinefotocolor, etc., and preservation separations.
09- Negatives for reproducing with filters
Made for adding the colour using filters and flashing - Desmetcolor- to the copies.
- Emulsions for colour
10- Triple-layer emulsions with integral mask
11- Triple-layer emulsions without integral mask
12- Colour lattice systems
Kodak, Agfa, Dufay
13- Systems on reversal emulsions
Kodachrome, Ektachrome, etc.
14- Technicolor copies
15- Dascolour, Cinefotocolor, Gasparcolor copies, etc.
16- Desmetcolor copies and copies from other systems used in restoration
Electronic image colour systems
17- PAL
18- SECAM
19- NTSC
20- Others

The following three tables are complementary.

TABLE 17 - SILENT/SOUND STOCK
This table deals with sound found on the stock inspected.
01- Silent
Stock from films with no sound. Note the image stock must be supplemented with sound stock.

02- Silent, Blank Track

Silent film image stock reproduced by reduction in 1:1.37 format or incorrectly reproduced by clipping the image located in the sound area.

03- Mono sound film

04- Stereo sound film

05- Sound film, Blank Track

This classification is set aside for image stock from sound films which have the space for sound; because this stock has no sound (like a cutting copy) or when it is inspected and classified separately from the sound stock completing it.

TABLE 18 - IMAGE-TO-SOUND RELATIONSHIP

01- Image and sound on one same photographic support (Com-Opt)
02- Image and sound on two separate photographic supports (Sep-Opt)
03- Image and sound in different emulsions on one same support (Com-Mag)
04- Image and sound on separate supports with different emulsions (Sep-Mag)
05- Sound on two emulsions on the image support (Com-Opt/Com-Mag)

TABLE 19 - SOUND SYSTEMS

For Com-Opt/Acom-Mag stock, the optical track type would be indicated in this table.

- Optical systems

01- Variable density
02- D.V. two-track
03- D.V. two-track in push-pull
04- One-sided variable area
05- One-sided V.A. two-track
06- One-sided V.A. in push-pull
07- Two-sided variable area
08- Two-sided V.A. two-track
09- Two-sides V.A. in push-pull
10- Duplex variable area
11- Double or triple duplex variable area
12- Two-sided variable area multi-tack (systems with 7 or more tracks)
13- Analogue stereo variable area
14- Analogue stereo + Sony SDDS
15- Analogue stereo + DTS
16- Analogue stereo+Dolby SRD+ SDDS
17- Analogue stereo + Dolby SRD + DTS
18- Analogue stereo + Sony SDDS + DTS
19- Analogue stereo + SRD + SDDS + DTS
20- Analogue stereo + Dolby EX
21- Analogue stereo+ Dolby EX+ Sony SDDS
22- Analogue stereo + Dolby EX + DTS
23- Analogue stereo+Dolby EX+SDDS+ DTS

- Magnetic Sound

24- One magnetic track on the image support
25- Several magnetic tracks on the image support
26- Perforated magnetic supports
27- Unperforated magnetic tapes

5.4 - Stock Condition and Continuity

The setting out classification tables is aimed solely at facilitating the retrieval of information which may serve to statistically study the main conservation-related variables of the stock and, in the case of the projection copies, to indicate the problems which may condition this use.

On attempting to enter the results of the analysis of a certain stock's condition into tables, one must bear in mind that there is no possibility of setting up a system of coding that satisfactorily describes the variables related to the condition of a certain stock, and that, these variables may additionally vary following each use or due to the mere passing of time.

Due to all of the above, those archives which decide to use tables to entering the stock conservation data must avail of those tables of the necessary elements for the technician who is making the inspection to be able to set out his/her judgement in detail as to the overall condition of the stock, as to the general condition of the support and of the emulsion and as to the continuity of the film, and additionally, as to those elements which are taken into consideration in each one of the tables.

In general, unless the type or importance of the damage sustained differs greatly from one roll to another, it seems preferable for the condition to be defined in keeping with the most serious situations which each one of the elements in question are detected in the stock as a whole.

More detailed descriptions of the condition of the stock and of the differences between rolls can be added in the "remarks" sections.

The technician who is making the inspection of a certain stock's condition must know the archive's anticipated use for the stock in question.

On conducting the inspection, for example, of a release copy, the evaluation which must be made regarding its condition will differ greatly from when the copy in question is intended for use for projection purposes than when it is an important stock for the preservation of the film.

The archives have to set out the criteria for making the inspections in keeping with the stock's anticipated use, basing themselves on the fact that the concepts which can be used to define the condition of the stock have very different meanings when a copy for projection, a duplicate release negative or a certain stock which is to be used for restoring a film are being inspected.

5.41 - Overall Condition of the Stock

The judgement of the technician making the inspection of the stock must be given by combing many elements and cannot be entered by means of tables. Even a recently reproduced stock may have photographed damage or be incomplete.

5.42 - Overall Condition of the Emulsion and Support

This set of tables has to do with those processes which may have a bearing on the entire film.

For videotapes, perhaps it is in this set of tables in which the information regarding the condition of the cassettes housing them must be entered.

TABLE 20 - OVERALL CONDITION

01- New stock

When certain stock is classified as "new" in this table, it should be possible for the system which manages the database to eliminate the need of scanning the other tables within this same set of tables.

02- Judgement

The judgement of the technician inspecting the stock in question.

TABLE 21 - CHEMICAL DEGRADATION OF THE SUPPORT

This refers to the degradation processes in the nitrates and the acid degradation of the acetates.

01- Good condition

- Celluloid supports

02- Latent degradation

Stock for which the red alizarin test provides good prospects for conservation of less than two years.

03- Inactive degradation stains

Stock damaged by degradation processes which are not active (the damage is dry) at the point in time at which the inspection is made.

04- Active degradation

Of any degree and extent.

- Acetate supports

05- Latent degradation

The tests show that the process of an increase in acidity has started, but without the supports showing any outer signs of degradation.

06- Self-catalysed degradation

The acidity tests show that the degradation process has progressing beyond the point of self-generation.

07- Advanced degradation

Stock which is warped, softened or embrittled, has plasticizer crystal florescence, etc.

-- Remarks concerning the chemical condition of the support

TABLE 22 - SHRINKAGE / CURLING

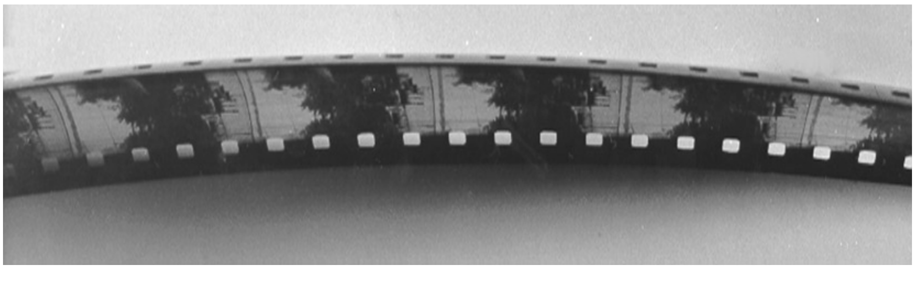
The importance which shrinkage may have for certain stock must be evaluated considering it in conjunction with the curling and other deformations due to the same cause.

01- Good condition

02- Slight shrinkage

Stock shrunk by 0.3%-0.5% which has no curling or waving.

This situation is the maximum permissible for most projectors and for reproduction in continuous contact printers.



F. 159a
Extreme curly and fragility
The base bents down in both directions and the film cannot be flatten without breaking.

03- Serious shrinkage

Stock shrunk by 0.5%-0.7% which has curling or waving which is not too pronounced.

The films in this condition can still be reproduced in slow, step printers, but can solely be shown using specially-designed equipment.

04- Very serious shrinkage

Stock shrunk by over 0.7% or which has minor shrinkage but major curling, waving or embrittlement.

Films not suitable for showing and which can solely be reproduced in printers equipped to work with shrunken stock.

05- Extremely fragile / Crystallisation

Stock which may break apart on solely shift position on winding.

-- Remarks concerning the shrinkage of the support

F. 159b: Crackling
The shrinkage of the base and the emulsion produce cracks in all the emulsion side.

TABLE 23 - COLOUR FADING

01- Good condition

02- Starting to fade

Stock showing some change in colouring (greenish skies, whites with pinkish tinge, etc.)

The copies in this condition could still be suitable for showing.

03- Serious fading

. Stock the colours of which are no longer representative of the original but on which the presence of the different colours can still be seen.

04- Very serious fading

Stock on which the blues or yellows can no longer be seen.

- Remarks on the chemical condition of the support

5.43 - Occasional Damage Having a Bearing on the Image or Sound

These tables are only fully valid when involving release copies.

In this set of tables, the classification "Good Condition":

- When copies to be used for projection purposes are involved, this does not mean absolutely no damage to the stock, but rather that the existing damage does not compromise the quality of a public showing.
- When conservation, reproduction or restoration stock is involved, this classification would imply that the stock is in perfect condition or has only some minimal damage not requiring any special treatments.
- On the projection copies, the existing physical damage to the stock will be considered jointly with any other damage which may be reproduced. For conservation, reproduction or restoration stock, these two types of damage are indicated separately.

TABLE 24 - STAINS

01- Good condition

02- Needs cleaning

This classification is logically tentative and solely valid for projection copies. After the cleaning has been done, the new report would place the film in question under the corresponding classification.

-- Remarks

In this section, to describe these types of damage, the classic terms (Grease spots, Dust, Liquid, Moisture, Rust Stains; Raised spots, Runs, Developing water; Single spots or combined spots. Edge stains, etc.) combining them for a comprehensible description.

F. 160a
Defects of duplication
[1] Enter of light in positive.
[2] Failure of the sound lamp in negative.

F. 160b - Defects of duplication
[1] Mosquitos on the negative. [2] Thread on the negative. [3] Defect during the drying of the negative.

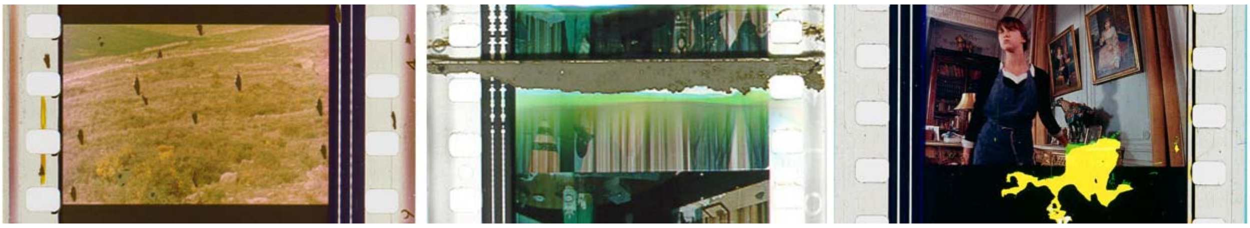


Figura 160c – Stains
[1] Splashes. [2] Paper stuck in a splice. [3] Pulled up emulsion.

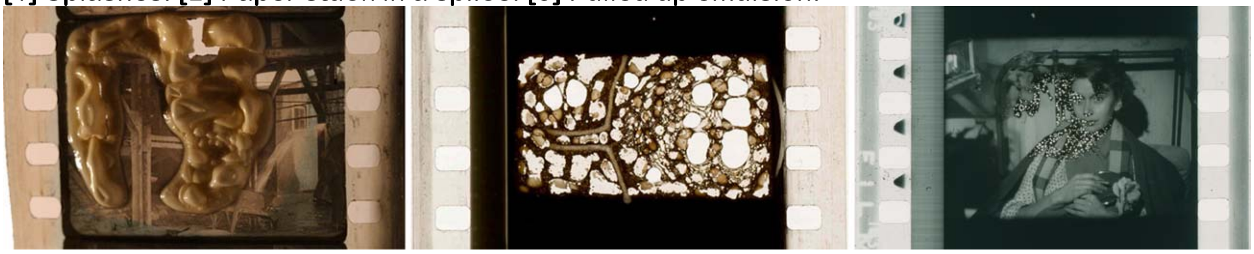
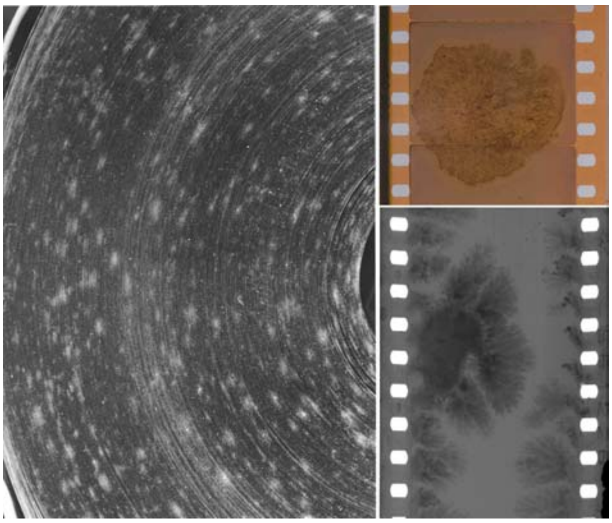


Figura 160d - Projector burns
[1] Burn on a celuloide film. [2] Burn on a security film. [3] Burns in the high density part of the central circle of the frame, in all the film, by failure of the anticaloric filter of the projectors.

TABLE 25 - MICROBIOLOGICAL CONTAMINATION

01- Good condition
02- Individual damage
03- Damage affecting the sound
04- Damage affecting the image
05- Overall damage
-- Remarks

Both for release copies, as well as for all other stock, until some acceptable definitions are set out, descriptive terms will be used to denote the importance of the effects of this degradation on the film. For example: cottony florescence on the surface of the roll, damage noticeable by transparency or by reflection, damage affecting the structure of the gelatine layers as regards the colour emulsions, etc.



F. 161
Microorganisms
Development of fungus outside of the reel and damages of the image.

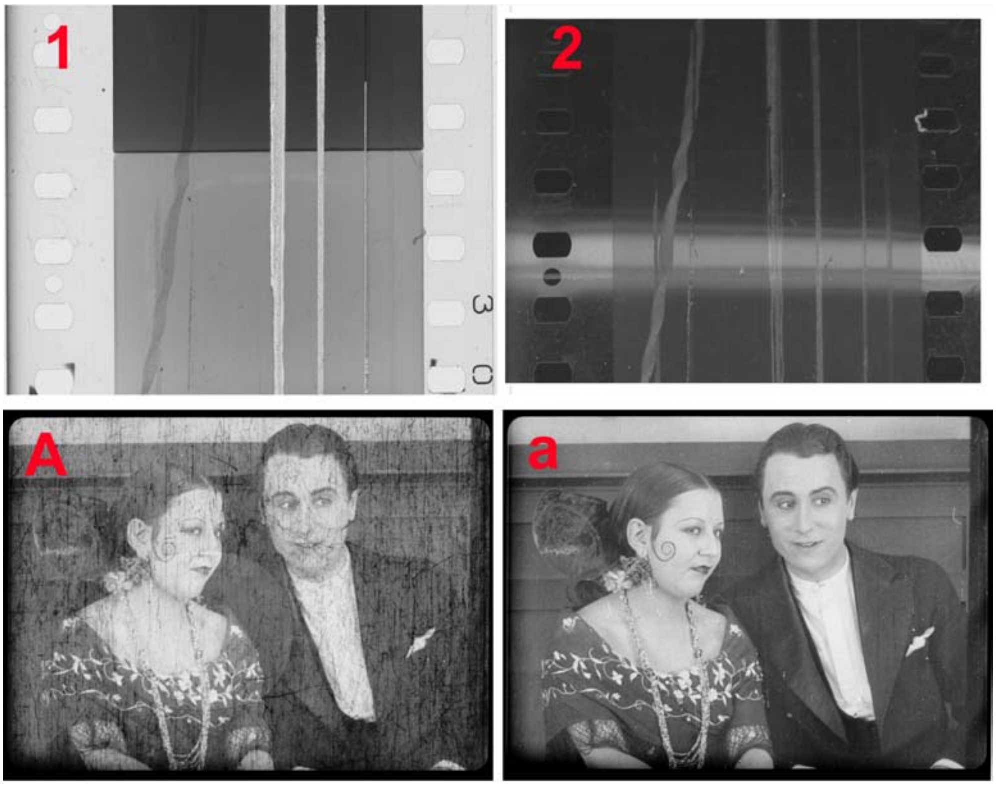
TABLE 26 - SCRATCHES

01- Good condition
For copies to be used for projection
02- Slight damage

Scratches of any type and positioning which do not noticeable interfere during showing

03- Serious damage

For black and white emulsions: medium scratches of any type, single scratches or groups of scratches on the edges of the frame and groupings of noncontinuous scratches and minor damage which can be seen in the form of "heavy rain".
For colour emulsions: fine scratches which have torn away one or two layers of colour.



F. 162
[1] [2] View by transparency and by reflection of scratches made on boyh sides of the film.
[A] [a] A frame reproduced at dry and in liquid printer gate.

04- Very serious damage
Single or groups of wide scratches of any type forming "curtains".
In colour emulsions, medium scratches which have torn away one or two layers of colour.

Stock for reproduction

05- Slight
Individual damage which does not require wetgate reproduction

06- Serious
Damage requiring wetgate reproduction

07- Very serious
Damage which, due to its size or due to its having torn away some layer of the colour emulsions, cannot be reduced by means of wet printing.

-- Remarks
Both for release copies as well as for all other stock, the classic descriptive terms (Gloss, emulsion or reproduced scratches), Thin or thick scratches, Lengthwise or crosswise scratches, Continuous or noncontinuous scratches, Single, Rain or Curtain scratches, etc.) will be used, combining them to provide a clear description.

5.44 - Damage Affecting the Physical Continuity of the Stock
Continuity must be dealt with related to different aspects when evaluating stock for showing or for reproduction.

A set of tables is set out below covering the different types of damage which have a bearing on stock continuity, in addition to a final table for stock evaluation purposes. Nevertheless, for many archives, it may be more suitable to bypass these tables and specify this aspect in "free text" form.

The last two tables in this group are provided for evaluating the importance of the combined effects of the damage as related to the continuity-related appearance of the stock in question.

TABLE 27 - DAMAGE TO PERFORATIONS AND EDGES

01- Good condition
Damage caused by use which does not affect the stock's integrity. (i.e. Certain perforations which do not jeopardise the stock during showing or reproduction).

02- Serious damage
Stock with sets of damaged or broken perforations or even some missing perforations which can be repaired to afford the possibility of the stock in question being used.

04- Very serious damage
Stock showing damage which cannot be repaired without causing losses in continuity or without the repairs affecting images or sounds.

-- Remarks
The classic descriptive terms (Pulled or split perforations, Open or repaired holes, Torn or missing perforations, etc.) are to be used, combining them to provide a clear description.

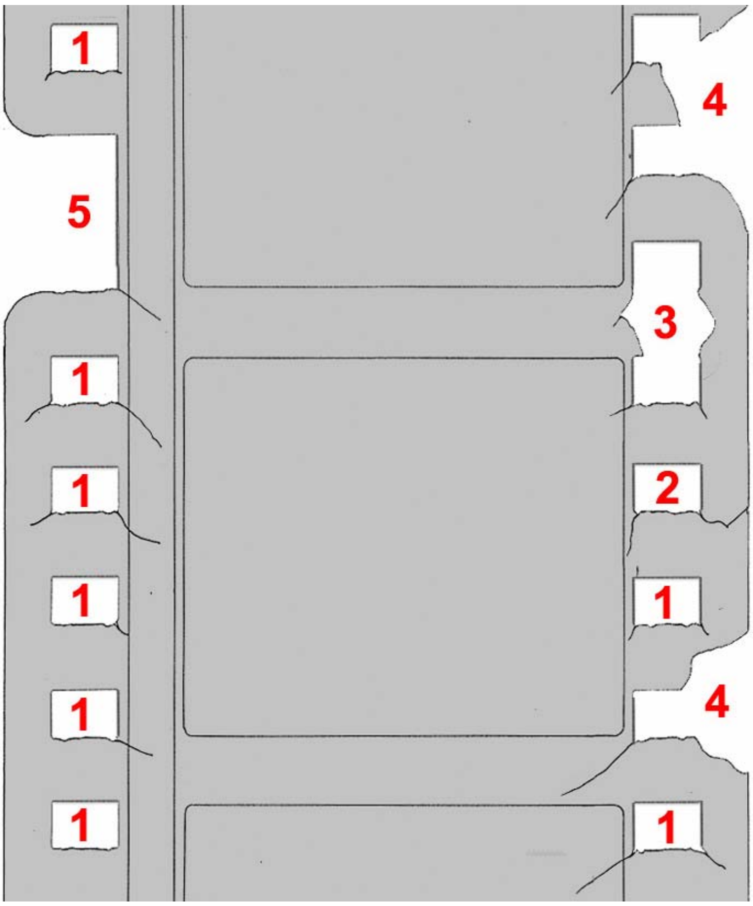


Figura 163
Damages in the perforations
[1] Ripped perforations.
[2] Open perforations.
[3] Run perforations.
[4] Pickets.
[5] Picket repaired in the projection booth.

TABLE 28 - PROTECTIVE TAILS AND PROJECTIONIST GUIDES

This table is related solely to whether these protective elements are in place and are in good condition.

01- Good condition

02- Tails/Guides loose

03- Tails/Guides worn or missing

TABLE 29 - BREAKS

01- Good condition

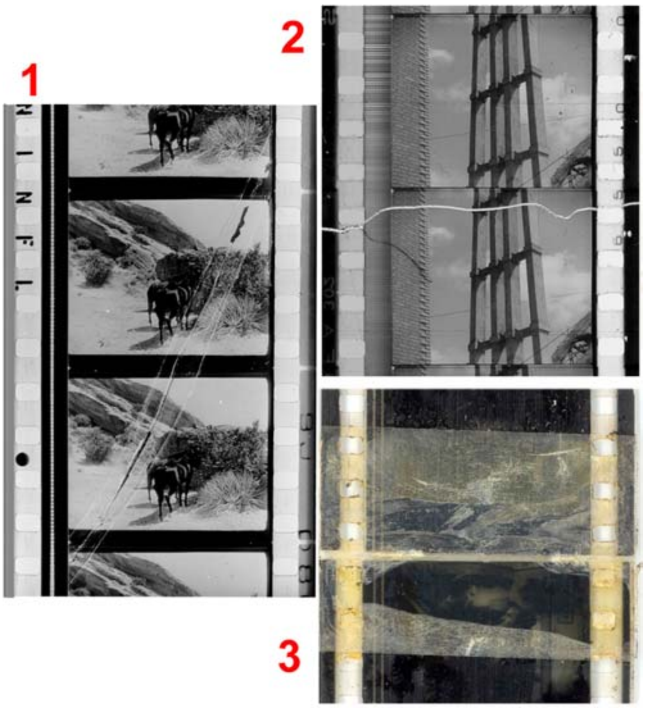
Films have no breaks

02- Clean breaks

Crosswise damage which can be repaired without giving rise to any loss in continuity or without losing more than one frame.

03- Tears

Breaks which cannot be repaired without affecting image or sound or doing away with more than one frame.



F. 164
Breaks/Splices
[1] Break repaired in negative.
[2] Break repaired with sellotape.
[3] deteriorated autoadhesive tape.

TABLE 31 - SPLICES

01- No splices

02- Splices in good condition

03- Adhesive tape splices which must be redone.

04- Cemented or heat-welded spices which must be inspected or redone.

TABLE 32 - CONTINUITY- DAMAGE EVALUATION

01- Good condition

New stock or stock not damaged to the point of its continuity being noticeably affected.

02- Limited damage

Stock showing some damage seen as breaks of very little importance in the continuity of the sound and movement.

03- Loss of continuity between rolls

Stock showing damage which noticeably affects solely the continuity at the beginning and end of the rolls.

04- Serious damage

Stock which has some limited damage which however gives rise to major discontinuities in sound and image or which shows damage of very little importance in multiple areas which seriously hinders viewing continuity.

TABLE 33 - CONTINUITY - INCOMPLETE STOCK EVALUATION
01- Sections or rolls missing
02- Missing sound sections or rolls
03- Missing image sections or rolls missing
04- No sound
05- No image
06- Only snatches

5.5 - Possibilities of Use

The following table takes in only some of the stock or film conservation situations affecting their use. The archives must also consider administrative or proprietorship-related type problems.

It is important to bear in mind that some of these classifications are established for the film and are used for all the other materials.

TABLE 32 - STOCK'S POSSIBILITIES FOR USE
01- Basic conservation stock
(Stock classification)

- Original negatives, Reversal positive originals and Video masters which are the original for a certain edition of the motion picture in question.
- Good-quality positive duplicates, even when the original negatives of the motion picture in question are conserved.
- Good-quality negative duplicates, when the original negatives are not conserved or are in poor condition, if there is no good-quality positive duplicate.
- Positive and negative duplicates in any condition and the release copies or the production stock when they are the most original stock conserved of the motion picture in question.
- Copies made for the premiere of the motion picture in question, even when they are in very poor condition, if they continue to have some of the original photographic characteristics.

02- Stock for reproduction
(Stock classification)

- Negative stock suitable for the reproduction of the film, when there is another good-quality positive or negative stock classified as the basic conservation stock.
- Video master copies available for use in reproduction.

03- Archive file copy
(Stock classification)

- Top-quality release copies, the use of which has been limited to the archive theatres or to loans involving special safeguards.

04- Access copy
(Stock classification)

- Copies suitable for the normal use of the film for theatre video viewing purposes.

05- Access copy as per report
(Stock classification)
Classification for copies pertaining to films which are conserved on other stock or by other archives of which the archive has no Access copy.

- Those copies which, due to their condition (scratches, faded colour, etc.) or due to their flaws in continuity, would entail major changes in how the film is seen by viewers.
- Those copies pertaining to versions which the archive considered to be incorrect.
- Those copies pertaining to films which, as a result of their being conserved solely in pieces, cannot be shown without warning the viewing public of these flaws.

06- Pending restoration

(Classification for the film)

Films the originals of which have not been located or have been destroyed.

- This would apply to all of the located stock of the film in question, up to the making of a basic conservation stock.

07- Reproduction problems

(Classification for the film)

Classification for films produced using systems which require special facilities for their reproduction or of which there are no standard negatives available.

- This would apply to the original stock, matrixes and archive copies of motion pictures filmed using systems such as Technicolor, four magnetic track Scope, Vistavision, Techniscope, etc.

Conservation strategies

Starting with the knowledge of the materials' characteristics, all decisions on long-term conservation are based on the study of the options which each archive has for establishing and controlling the conditions of temperature, relative humidity, ventilation, cleanliness and lighting of its stores and work places, paying special attention to maintaining the stability of the selected conditions, to preparing the films for storage and use, and to the safety of people and materials.

6 - Conservation of Film in Rolls

As was pointed out at the beginning of the chapter devoted to films, a film allows the recording long strings of data, and despite the fact that a film may be hundreds of meters long, it can be wound and handled relatively easily.

Winding is a basic procedure for film storage. The term motion picture storage actually means the storage of rolls of film, and this type of storage will have a bearing on many aspects of the conservation of the film.

A film can be described as being a "sandwich" of materials, comprised of two layers (emulsion + support) securely affixed to one another, with many different chemical and mechanical properties.

A two-layer "sandwich" will always be mechanically unstable, even if the two layers were to be equal. Stable "sandwich" material (i.e. plywood or insulating panels) is comprised of an uneven number of layers (3, 5, 7) such that the symmetrically opposite layers will offset the stresses which the differences in moisture or temperature can cause in the opposite layers.

The two layers of motion picture film are totally different. The support layer is 10-20 times thicker than the emulsion, is mechanically stronger and tends much less toward absorbing or giving off moisture than does the emulsion.

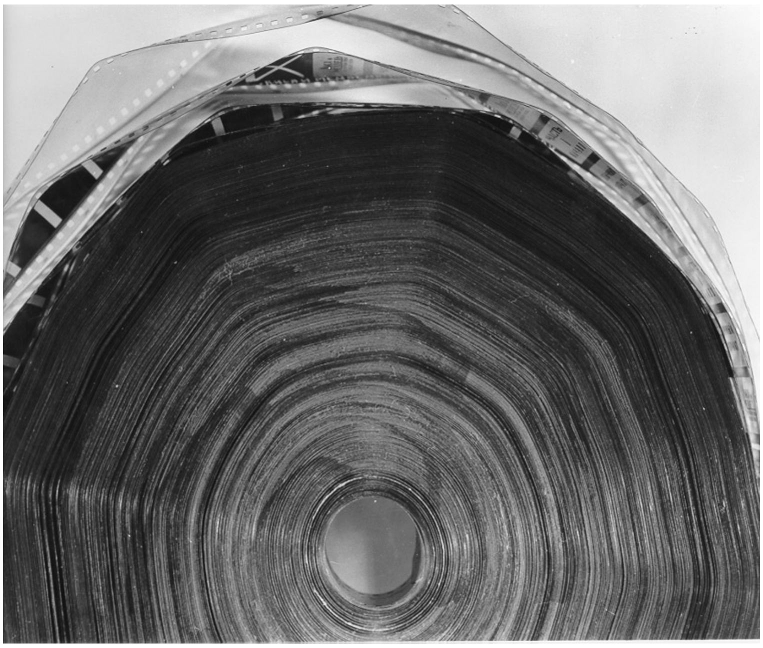
Leaving aside the processes derived from the chemical degradation – which also cause dimensional changes – if we analyse the behaviour of a roll of film, which gives off moisture, and so contracts, or which absorbs moisture, and so expands, this will reveal some of the mechanical aspects involved when conserving rolls of films.[151]

1.- If the film loses moisture, the emulsion thins. However, the emulsion will not only become thinner, but rather shorter (shrinking) in all directions. As

[151] Setting out hypotheses based on such simple parameters as giving off moisture and contracting or absorbing moisture and expanding is overly simplified, but even so, in order to be able to work through these hypotheses, it will be necessary not to take into account many of the processes involved. If were considered jointly all of the chemical processes related to contraction were to be taken into account, with the changes in moisture content or with the dynamics of the movement of one convolution which changes in length which are involved, it would be totally impossible to set out any working hypothesis at all.

the emulsion is joined to the support, which is much stronger and thicker, the only direct effect will be the lowering of the pressure between convolutions.

- When the support continue to lose moisture, it will also need to turn to shrinkage in order to adapt its structure to the loss of matter, and given that the loss of dimensions cannot be homogeneous, the support will have to bend.
- If it bends laterally - in principle, it could bend on either one of its two sides - but, as the emulsion has already shrunk, the slight tug of the emulsion will "convince" the support to bend toward that side.
- If the film were not wound into a roll, it would bend directly toward the side on which the emulsion is located, which is defined as "curling", but the film is wound, and the geometry of a spirally wound plane do not allow for any crosswise bending.



- As the support continues shrinking, the entire roll of film will lose shape. The stresses caused because it is impossible for a plane to bend in two directions at the same time will be resolved by forming "round corners" and straight sections. The convolutions will no longer be "nearly circular" to then become polyhedral.

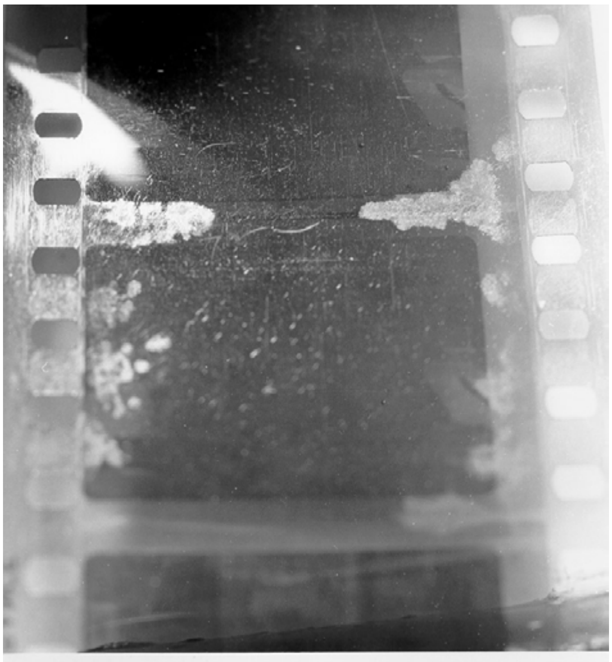
Of course, if this loss of shape continues long enough, it will then be impossible to restore to its original state.

2.- As regards the opposite hypothesis, when a film absorbs moisture, the emulsion expands. One of the most important characteristics of gelatines is their ability to expand during photographic processing; their expanding while wound however being an unwanted characteristic.

- Each layer of emulsion must expand within the confines of two much harder layers of support. Besides, the emulsion is neither homogenous nor its surface smooth, the metallic silver being much harder than the gelatine and clustering in the denser areas which are thicker than the transparent ones or those of average density.

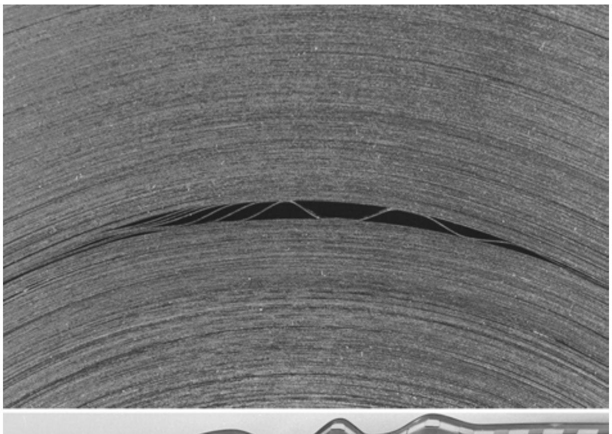
"Ferrotyping" is a term related to gelatine's irregular flattening effect in the denser areas of each frame, this flattening becoming visible to the naked eye in the form of "bright spots" on the film and as image "saturations" if viewed in transparency.

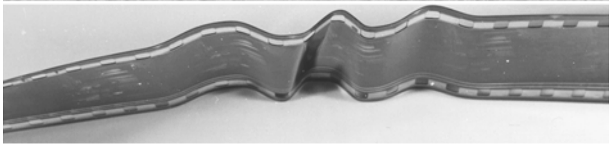
3.- Apart from the above, although these be phenomena which affect the entire roll, one small part of each convolution of the film, the edges, comes into direct contact with the exterior, and the amount of moisture lost or absorbed along the edges of each convolution will differ from that which takes place on the inside of the convolutions.



Thus, for example, it becomes obvious how the differences in absorption between the convolutions covered or exposed by the "radii" of a reel, or at the start of end of rolls, lead to differences in film shape loss. Or it is also obvious how moisture (and microorganisms) get into the film from along the edges and make their way toward the less dense (thinner) areas of the emulsion (i.e. along the frame line between frames on a negative).

4.- If we now consider the geometrical behaviour of a large film, wound in a roll which loses length (longitudinal shrinkage), we will observe that in order to adapt its wound disposition to its new length it can only resort to two processes: sliding along the roll until attaining a smaller diameter or, reducing its diameter increasing the pressure between convolutions (the winding tightens).





- And, as we can observe by studying the wound characteristics in films, which have remained unwound for many years, both processes are produced simultaneously.

-The film slides to reduce its wound diameter. Naturally, this sliding cannot be uniform and can be interrupted by any obstacle (splice, perforation break, etc.); besides, the increase of pressure between convolutions makes the sliding more difficult.

- Since, as the film gets shorter, it also loses thickness (to which we must add the thickness lost by emulsion), when the shrinkage is produced by loss of moisture, the increase of the pressure between convolutions will manifest itself very late; but if the shrinkage derives from the chemical degradation (for example: evaporation of plasticiser), the increase of the pressure produced by shrinkage will manifest itself quickly, with an increase of temperature, causing effects such as "ferrotyping"[152] or the ones pointed out in the section 1.21, devoted to dimensional stability, and in the 1.411, devoted to celluloid supports.

Under normal storage conditions, all of the processes which can derive from the wound film preservation evolve very slowly, and though its effects may be negative, even destructive, the materials shall remain wound in the same way for many years; therefore for the purposes of cultural heritage conservation, on a very long-term basis, this question of a film staying wound the way it was originally rolled may be crucial.

From this standpoint, the recommendations which have been made concerning the position of the emulsion during the winding process or regarding how tight films should be wound are apparently much less important than the possibility of periodically rewinding each film. With emulsion located "facing inside" or "facing outside", the mechanics of emulsion and support contraction or expansion and the destructive processes related to low and high pressure among convolutions will progress as discussed as previously discussed in this document.

For the very long-term cultural patrimony preservation purposes, the only thing which can check the damage which may be caused by the effects of the winding process building up over the course of time will be unwinding and rewinding the film every certain number of years, thus giving the film the chance to take on the shape-related position corresponding to its actual length, releasing the stresses and strains and allowing the gases built up inside the film to be released and; if it is deemed suitable, reversing the positions of the emulsion and of the start and end of the rolls.

Winding tightness is also of major importance for video tapes

Different researchers report that the effect of print-through is faster and stronger on two-inch and one-inch video rolls than on cassette tapes. This may be due to the fact that the mass of these rolls, which is much greater than the mass of cassettes or tapes being related to this difference, but what indeed undoubtedly has a bearing on thereon are the different winding tightness required by one type of stock and the other.

Placing tapes inside cassettes has many added advantages. Encasing tapes inside cassettes made it possible to safely use tapes considerably thinner than those required for uncased rolls. Cassettes are storage and winding devices which, when properly used, ensure that the tape will run along the right paths

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[152] Paul Read and Mark-Paul Meyer (editors): "Restoration of Motion Picture Film". Butterworth-Heinemann. Oxford, United Kingdom, 2000.
3.9 Ferrotyping: Ferrotyping is synonymous to 'glazing': a method to give photographic papers a shiny surface by drying the emulsion on a hot steel surface. In cinematography 'ferrotyping' is a term to describe glossy marks on emulsions. These changes in the normal matt appearance of the emulsion are caused by a combination of tight wounding and humid storage. The damp lets the emulsion swell and when it is pressed against the adjacent convolution it takes on its smoothness and glossiness. The effect is often local, in irregular, patchy shapes.
Ferrotyping is not serious in itself, as the photographic image is unchanged. Sometimes the ferrotyped areas have sharply edged boundaries which show on the image as dark wavy lines. As these lines might be visible on a next generation of film they should be removed before duplication. Some ferrotyping is easily removed by a water wash. To quicken and intensify the treatment a solution can be used that swells the gelatine. For this purpose a re-washing solution, used for emulsion scratch removal, can be helpful.

and will be wound correctly (if the recommendation is heeded of fast forwarding the tapes all the way to the end after use and then rewinding them completely at one same speed before putting them away). And, additionally, cassettes are a case, which safeguard the tapes from coming into contact with the hands of those handling them.

7 – Conservation conditions

Temperature, relative humidity, cleanness and ventilation constitute a unique set of conditions and the decisions that are taken on each of these parameters will affect all the others.

7.1 - Relationship between temperature and conservation

All the materials – of no matter what kind – can only maintain their functional characteristics within a certain range of temperatures. At temperatures above or below this range they undergo transformations which in many cases can be irreversible.

Cinematographic materials are especially sensitive to the action of heat and their functional characteristics can be modified by only moderately high temperatures; nevertheless, the temperatures at which the transformation of materials can take place are very much higher than those normally to be found inside the stores of an archive; therefore, when talking about adequate temperatures for the conditioning of conservation stores, they are temperature ranges below those necessary for affecting the chemical stability of the materials.

7.11 – Thermal degradation

Heat constantly flows from hotter matter to that with a lower temperature, though the temperature does not vary uniformly throughout the entire mass of a material that is being heated or cooled. If a reel of film is absorbing heat from its surroundings, it will be the outermost layers which first undergo a temperature increase and which will later on radiate sufficient energy for heating up the entire interior of the reel.

Heat absorption, the increase of the temperature in the material, takes place molecule to molecule – in an individualised way – as each molecule absorbs the heat received from the outside or from its neighbouring molecules. So, by means of this mechanism, in all materials, even in those that are being stored at well below critical temperatures, there can exist molecules that have absorbed a sufficient quantity of heat (energy) for initiating their degradation.

Chemical reactions, which break the structural chains of materials, release energy (exothermic reactions) and if the input of heat from outside is maintained, the heat produced by the molecular breakage will increase the temperature of the material, accelerating and propagating the degradation process (autocatalytic processes). So, a degradation reaction initiated in a few molecules, in a material located at relatively low temperature, can spread, producing more and more heat, affecting neighbouring areas first and then finally the entire material.

When one talks of the temperatures at which the material should be stored, one is talking of storage temperatures capable of reducing the number of molecules reaching the transformation temperatures; and one is talking of temperatures so low that, even with the help of the heat produced by molecular splitting, they are incapable of sustaining and accelerating the degradation process.

7.12 - Freezing

Conservation at low temperatures is a basic aim in any archive policy, but there arises here the search for another limit: how low can storage temperatures be?

In 1985, two Kodak scientists, D. F. Kopperl and C. C. Bard, published a work in which they tackled this problem theoretically and experimentally[153] for films with a triacetate base.

Basing themselves on earlier works by P.I. Rose, they found that the percentage of water contained in the gelatines (around 20% of the volume) was sufficiently low so that the water remained attached to the molecular chains of the gelatine and did not undergo its own independent freezing process with the characteristic increase in volume. This finding solved once and for all one of the most widespread doubts about the conserving efficacy of freezing.

When carrying out their own experiments, Kopperl and Bard used modest sized reels of positive and negative Kodak films, completely new but exposed and processed, and, in the case of copies, projected. The samples were preconditioned at 24ºC and 40%RH, with some being placed in sealed containers and others in ventilated containers.[154]

During the tests, each reel was subjected to 100 freezing cycles at -24ºC, and the controls that were conducted (every 25 freezing cycles) were unable to detect any variations in the physical, chemical or photographic characteristics of the films.

Bearing in mind the study by Kopperl and Bardar, the freezing of films is a safe and effective technique and its results are undoubtedly totally reliable if we pay attention to the conditions of the films used in the empirical tests; though the conditions of the films that the archives have to preserve are infinitely more diverse than those verified by means of these experiments.

Ignoring the fact that there exist many types of triacetate and that, even in photographic gelatines (a much more homogenous material than triacetate), there exist major differences in their composition and properties; the immense majority of films which the archives have to conserve cannot be classified as "new films".

In the archives, only the duplicates and prints specifically obtained for preservation will meet the conditions of having been produced on a single type of raw stock and of always having been used under controlled situations; all the other materials (negatives, duplicates or release prints) arrive at the archives following multiple use, with multiple damage, with stains and dirt of all types and with humidity contents and, above all, degradation situations, that are absolutely uncontrollable.

And all this diverse variety of materials, of damage and of repairs, of stuck particles and the remains of grease, can represent an immense variety of behaviours towards freezing which can even result in damage for the conservation of the films.

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[153] D.F. Kopperl and C.C. Bard "Freeze/Thaw Cycling of Motion-Picture Films". SMPTE Journal - August, 1985 Issue, Volume 94, Number 8

[154] These authors point out that the preconditioning of the films must never be done at below 25%RH, since at such low humidities the fragility of the films increases.

Preconditioning the materials at humidities between 20 and 25%RH, in order to control their humidity content, is an essential task for conservation in freezing conditions but, apart from in fresh films (those that are recently manufactured and processed) and which are completely clean, control over the humidity content is not a sufficient condition[155].

Prior to preconditioning for freezing, the materials must be checked, determining the homogeneity of their bases and emulsions, the nature and importance of the damage (and of the repairs which have been made), the nature and extent of grease stains and mineral remains (dust and stuck particles) and the possibility of cleaning and, finally, detecting the possible existence of active processes of degradation which are modifying the characteristics of the materials.

Carrying out this entire range of checks on each of the reels of material that have to be frozen (and, of course, following the actions deriving from the results of eachcheck) requires an effort and manpower that can be impossible for many archives.

Moreover, some of these controls, such as cleaning away the remains of grease and minerals, entail risks for the materials, risks which it will only be necessary to accept following a case by case study as part of the reproduction or restoration processes[156].

The conservation of materials under freezing conditions can be a wholly satisfactory system, but it is not a simple one. Archives that have produced good results by means of this system have done so by applying a wide range of complex procedures for the selection and preparation of the materials and, above all, they have had to be capable of guaranteeing continuity in the maintenance of the conservation conditions.

7.13 - Conservation at low temperatures

Naturally, between the temperatures for freezing conservation (for example, -5ºC) and those considered as standard temperature for a working environment or for the storage of many archive materials (around 21ºC) there exists a wide range of temperatures. Therefore, establishing the relationship between lowering the temperature by each degree and lowering the probability of thermal degradation in the materials is a question that acquires great importance for archives. Unfortunately, the variety of factors involved in degradation only permit certain guidelines of limited scope to be obtained.

In section one of this work, reference was made to the relationship existing between temperature and structural degradation of nitrocellulose bases. Herbert Volkmann[157], starting from studies developed by Kodak, pointed out that

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[155] In order to be able to achieve useful experimental results, the immense majority of laboratory studies have to be conducted with "fresh", new and recently processed materials. In studies conducted with “archive" materials, the differences produced by the aging and the impossibility of determining what the original characteristics of the materials were (and therefore, their degree of aging) do not permit homogenous results to be obtained.

[156] From an economic point of view, reproducing or restoring archive materials are processes so expensive that they wholly justify the undertaking of all of these tests and cleaning processes pointed out.

[157] Herbert Volkmann: "The structure of cinema films". In: "Preservation and restoration of moving images and sound" - Chapter 5. FIAF, Brussels, 1986.

reducing the storage temperature by 5ºC represents a 50% reduction in the production of gases from the nitrate.

This discovery constituted a guide of extraordinary importance for conservation but, simultaneously (as the quantitative importance of each of the reductions depends on 50% of the total quantity of gases being produced by the decomposition of the material), it also states that the conservation perspectives of each material in the archive is related not just to the storage temperature but also to its initial state of conservation.

In the field of triacetate bases, the Image Permanence Institute has developed a series of highly important works[158] aimed at increasing knowledge on the degradation processes of materials and the development of useful elements and systems for their detection and prediction.

One of these elements, the "Preservation Calculator" (a small computer program) permits predictions to be made on the durability of the materials, indicating the number of years the material will take to reach the irreversible " autocatalytic point"[159] in its degradation process.

Although this useful tool only aims to provide a guideline, it contains the results of important research and statistical studies and permits a relationship to be established between a drop in each degree of temperature and the increase in durability.

The program opens with its indicators located at 20ºC (68ºF) and 45% RH, stating a period of 50 years before reaching the autocatalytic point. Maintaining the level of RH and lowering the temperature a degree at a time gives the following table:

Increase in durability as a function of the temperature drop at 45%RH														
ºC	years	Increase	ºC	years	Increase	ºC	years	Increase	ºC	years	Increase	ºC	years	Increase
20	50	---	15	95	13	10	182	27	5	360	54	0	729	113
19	57	7	14	108	15	9	209	30	4	414	62	-1	842	132
18	64	7	13	123	17	8	239	33	3	476	72	-2	974	163
17	73	10	12	140	20	7	273	37	2	548	84	-3	1127	179
16	83	12	11	160	22	6	314	46	1	632	97	-4	1306	208
Produced with data obtained from the "Prediction Calculator" of the Image Permanence Institute												-5	1516	---

This table enables one to see that approximately each 5ºC drop in temperature doubles the durability expectations of the material and that also,

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Also in "Preservación". In: Bowser, Eileen y Kuiper, Jonh (edit.): "Manual para archivos fílmicos". Boletín CIDUCAL, nº 3, FIAF-CIDUCAL-UNAM, Mexico, 1981.

158 P.Z. Adelstein, J.M. Reilly, D.W. Nishimura and C.J. Erbland: "Stability Of Cellulose Ester Base Photographic Film": Part I - Laboratory Testing Procedures (SMPTE Journal, May 1992); Part II - Practical Storage Considerations (SMPTE Journal, May 1992); Part III - Measurement of Film Degradation (SEMTE Journal, May 1995); Part IV - Behavior of Nitrate Base Film (SMPTE Journal, June 1995); Part V - Recent Findings (SMPTE Journal, July 1995)

J.L. Bigourdan and J.M. Reilly: "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome". In "Les enjeux du 3ème millénaire". C.S.T. - C.N.C. Paris, 2000.

159 The situation of degradation in which the energy released by the breakage of the polymer chains of the triacetate is capable of sustaining the degradation independently of the input of heat from outside is referred to by the I.P.I. as the "autocatalytic point". In general, this situation is considered to constitute a point of no return in the degradation.

approximately, each 5ºC doubles the increase in durability implied by falling another degree more in the conservation temperature.[160]

7.2 - Temperature and relative humidity

The hydrolysis reaction constitutes the main mechanism in degradation of cellulose-derived plastic. This kind of chemical reaction is related to the presence of humidity and is accelerated when, due to the existence of high relative humidity in the warehouses, this leads to an increase in the amount of humidity absorbed by the materials.

Although it is considered that the activation energy (heat) necessary for starting up the degradation processes basically depends on the chemical stability of the material, the possibility of the degradation being initiated (and its speed of development) will be much higher if the storage takes place under conditions of humidity higher than 50%RH. So, for example, for the long-term conservation of processed colour films, ISO standard 18911[161] recommends temperatures of -10ºC in cases when the range of humidities could reach 50%RH and 2ºC if the humidity is reduced to a maximum of 30%RH.

Temperature and relative humidity are intimately related in the degradation processes of materials but, moreover, the concept of relative humidity now establishes a direct relationship between the amount of humidity existing in a particular ambience and the temperature that is registered at each moment.

The concept of "specific humidity" expresses the amount of water vapour contained in 1 kg of dry air.

The value of the specific humidity is represented by means of a pressure difference function, in which a separate consideration is made of the partial pressure of the water vapour and the total pressure of the volume of air being considered. This value varies with atmospheric pressure and is independent of the temperature. [162]

The relationship between a certain specific humidity and the decrease in the temperature reaches its critical point – saturation temperature / dew-point – when the water vapour condenses out as fog or dew in the atmosphere of the store or on its walls or the surfaces of containers and materials located inside it.

The percentages used for expressing the relative humidity represent average values for the entire mass of air being considered.

In any mass of air (at 50%RH, for example) there will coexist water molecules that are being transformed into vapour, along with volumes of water vapour that are condensing out as dew on surfaces.

A relative humidity close to 100% ought to be described as a situation of extreme fluidity in which, at any moment (depending on a minimal variation in the atmospheric pressure or of contact with a colder surface), any quantity of

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[160] The program "Preservation Calculator" is a creation of the Image Permanence Institute, developed with the aid of the National Endowment for the Humanities and the Andrew W. Mellon Foundation.

[161] ISO 18911-2000: "Photography - Processed Safety Films - Storage Practices". International Organisation for Standardisation, Geneva, Switzerland.

[162] The discussion of these concepts broadly follows the speech from Dr. Pere Ezquerra "Sistemas electromecánicos para la climatización de almacenes: características y consumos energéticos", given in the Seminar ARCHIMEDIA, on the vinegar syndrome, held in Madrid in January 2002.

water vapour existing in the air can reach saturation point and condense out as dew or fog.

The limit values of 100 and 0%RH represent situations that are virtually theoretical, and only achievable by means of laboratory techniques.

7.21 - Conservation under conditions of low relative humidity

Quantifying the importance which the decrease by each percentage point in the relative humidity can have for the durability of materials is an extremely complex undertaking.

The predictions that it is possible to make, by extrapolating the data obtained in experimental research, confirm that a decrease in the percentage of humidity has less of an influence on the stability of materials than that exerted by a decrease in temperature by one degree but, simultaneously, they also confirm that the influence of humidity can be decisive for their durability.

Among the conclusions of research conducted in Madrid[163], consisting of artificial aging experiments under different conditions of humidity and temperature, was a prediction of durability at 21ºC, based on the loss of viscosity and made via the Arrhenius equation.

The results obtained (35 years at 100%, 199 years at 60% and 228 years at 30%) can only be regarded as indicators of a trend, but they confirm what has been stated earlier: although the importance of very low relative humidities is less than that of temperature, their contribution to the stabilisation of materials can be decisive.

In "Preservation of Moving Images and Sound"[164] a comparison is made of the effects of decreasing temperatures and humidities on the durability of dyes. In the scale of temperatures, a drop from 24 to 4ºC is equivalent to going from a durability factor 1 to a factor 16. On the scale of humidities, dropping from 60 to 15%RH (which implies a much more drastic decrease than that indicated for temperature) will only represent a fourfold increase in the durability factor (from factor 0.5 to 2).

A final confirmation can be obtained with the aid of the program created by the Image Permanence Institute. In warehouses located at 20ºC, the differences in durability obtained by reducing the relative humidity from 50 to 25% only amounts to 37 years (going from 50 to 87 years), while they imply 72 years (from 95 to 167) under temperatures of 15ºC and reach 303 years (from 360 to 663) when the temperature control of this program stands at 5ºC.

In spite of everything that has been said, when talking about use of ambient conditions for the conservation of materials, the values of temperatures and relative humidities must be considered jointly and inseparably.

Another work from the Image Permanence Institute, presented in the Joint Technical Symposium of Paris by J.L. Bigourdan and J.M. Reilly[165], part of the experimental results (obtained by means of accelerated aging processes) are

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[163] F. Catalina and A. del Amo: "Los soportes de la cinematografía / Motion Picture Film Stock", Filmoteca Española, bilingual edition, Madrid, 1999.

[164] See: Textual Note XIII.

[165] J.L. Bigourdan and J.M. Reilly (Image Permanence Institute): "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome: Preservation Strategies for Acetate Base Motion-Picture Film Collections". In: Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000.

set out via a table relating temperatures and humidities via a time factor. In that table[166] a comparison is made of the values reached via successive drops in temperature, in situations of 50 and 20%RH, with increases close to five times being obtained in the time factor considered.

7.22 – Equilibrium of humidities

The fact that the specific humidity is represented as a function that relates pressure differences means that: if two air masses with different specific humidity are placed in contact, the water vapour will migrate towards the zones with lower pressure of absolute humidity (less humid) until a pressure equilibrium is achieved.

This migration has major consequences when aiming to achieve atmospheres with low relative humidity.

This process of reaching equilibrium, which takes place very quickly among air masses, also takes place (though much more slowly and with important differences in its development) if the difference in humidities is produced between, for example, a mass of air and a non-impermeable material such as gelatines.

When considering the humidity conditions under which photochemical films ought to be conserved, it is essential to place the characteristics and needs of photographic gelatines in first place.

Gelatines are very resistant to temperature variations, and require storage temperatures higher than 50ºC before their mechanical and optical characteristics start to change. Nevertheless, they are extremely accessible to action by humidity.

Photographic gelatines are designed to absorb several times their volume of liquid in developing baths and, of course, later on they retain this facility for absorbing and losing humidity. So, if intrinsic humidity (the water content) is an important factor in the characteristics of many materials, in gelatines it becomes a fundamental element.

In studies conducted by F. Catalina in the Instituto de Polímeros it was shown that the humidity contained in the emulsions of the films studied represented up to 1.5% of the total mass of the film.

Gelatines absorb (and release) humidity with much greater facility than the bases, and the variations in the humidity of warehouses will first of all have an effect on the gelatines.

When a mass of gelatine absorbs humidity, the pressure of the water vapour in the layer of air in direct contact with the gelatine drops; the humidity of the atmosphere immediately reacts, balancing out the pressures by means of "sending" more humidity to the surface of the gelatine layer which thereby returns to being in the necessary ambient conditions for absorbing a new "dose" of humidity. In a different process – though one with symmetric effects – a drier atmosphere will continually extract humidity from gelatines until equilibrium is reached.

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[166] See: Textual Note XIV.

7.3 - Ventilation at low temperatures and humidities

The economic investments needed for the construction and maintenance of acclimatised warehouses vary strictly according to the relative humidities trying to be achieved.

If it is not necessary to pay attention to the relative humidity and to the renovation of the air, then the construction and maintenance of cold warehouses or freezing chambers do not present any special degree of difficulty; on the other hand, when considering relative humidities below 50% together with high levels of renovation in the ventilation flow, then the decrease of temperature by each degree and of relative humidity by each percentage point will require an important increase in the economic investment needed.

7.31 - Renovation and recirculation of the air

Systems which combine cooling and humidity control function by means of treating air masses which are conditioned before being introduced into the warehouses.[167]

In order to reduce energy consumption, the construction of cold warehouses or freezing chambers requires thermal insulation systems that will reduce the influence of temperature variations from the outside atmosphere to a minimum. At the same time, the maintenance of RH levels lower than (or higher than) normal in the atmosphere of the warehouse makes it necessary to use impermeable sheets that prevent the exchange of humidity. In these systems it is also necessary to get the air pressure inside the store to be higher than outside in order to prevent the entry of unconditioned air.

The economically optimum solution would be achieved with warehouses that are totally insulated, in which the entrance of "fresh", unconditioned, air is reduced to the absolute minimum.

If it were possible to recirculate the same air mass continually, the reconditioning prior to each new recirculation of the air would be reduced to restoring the temperature and humidity which would have varied due to interaction with the deposited materials and with the warehouse itself, and the intake of non-conditioned air from outside would be limited to restoring the inevitable small losses of the system. But this type of working scheme (which would be really economical) is totally impossible.

7.311 - Ventilation as a conservation factor

As was stated in various parts of section one, the decomposition of cellulose (nitrate) bases produces nitrogen dioxide and nitric acid, these being gases which accelerate the degradation of materials; as occurs with the acetic acid produced by the degradation of acetates.

Both for reasons of conservation and for fundamental reasons of the health and safety[168] of personnel, all these gases have to be removed – as quickly as

[167] In this part, use is once again made of the criteria set out by P. Ezquerra in his speech given to the Seminar ARCHIMEDIA on the Vinegar Syndrome, in January 2002.

[168] All the texts on conservation, among them the works by Herbert Volkmann already cited, expressly point put that the accumulation of gases produced by the decomposition of celluloid in a closed environment can reach the point of creating an explosive mixture.

possible – and replaced with clean air. H. Schou[169] states that, in warehouses of inflammable materials, the air must be completely renovated a minimum of four times a day.[170]

Deficiencies in ventilation conditions also increase the danger represented by the proliferation of microorganisms (bacteria and fungi) on the films. Studies conducted by Dr. N. Valentín et al.[171] indicate that the growth in colonies of micro organisms becomes unrestrained in humidity conditions of 50% and with deficiencies in ventilation; this group of researchers confirmed that the proliferation of colonies was completely interrupted if the ventilation stood at the order of one complete renovation of air per hour, and recommenced (without modifying the humidity and temperature conditions) if the air remained for six hours without renovation.

If one is talking about storage under artificial acclimatization, the difference between four and twenty-four complete renovations of the air each day (the two values presented in the previous quotations) implies a genuine economic "abyss", the magnitude of which makes it evident that, in the fight against microbiological degradation, it is necessary to combine ventilation with the control and reduction of relative humidity. At the same time, these differences also make it clear that a good preservation warehouse will never be able to be totally isolated from the outside air, but will have a continually assured and defined flow of incoming air from the "fresh" air in the system.

Direct experience of the archive also demonstrates that ventilation can constitute a fundamental criterion for conservation.

Harald Brandes, in a paper presented to the Third Technical Symposium[172], set out a long list of cases of warehouses which, functioning in very different atmospheres and without artificial acclimatisation but with very good ventilation conditions, had managed to conserve nitrate or triacetate materials stored in them in a perfect condition.

7.32 - Filtration

The need to condition the air that will be introduced into preservation warehouses is not confined to humidity and temperature: the gases existing in the outside atmosphere can be directly harmful for the films.

Standard ISO 18911 mentions that products from industrial and urban contamination (such as sulphurous gases and ammonia, ozone and fumes from paints and solvents, as well as sulphur dioxide and other less common gases) are directly aggressive for photographic materials. All these gases reach their highest levels of concentration inside or in the vicinity of major industrial

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[169] Henning Schou, et al.: "Preservation of Moving Images and Sound". FIAF Preservation Commission, Bruxelles, 1990.
Also: Henning Schou, Harold Brown and others: “Preservación de imágenes en movimiento y sonido". Special edition of the Directorate General of Motion Picture Activities of the UNAM, Mexico, June 1992.

[170] For air renovation frequencies in safety base stores, Schou refers to the health and safety at work regulations in force in each country.

[171] N. Valentín, R. García, L. de Óscar and S. Maekawa: “Microbial Control in Archives, Libraries and Museums”. In Restaurator, nº 19 - pg.: 92 to 114. SAUR - Munich, Germany, 1998.

[172] Harald Brandes: "Are There Alternatives to the Traditional Air-Conditioned Film Stores?" In. "Archiving the Audio-Visual Heritage - Third Technical Symposium". Technical Coordinating Committee and Unesco; Ed.: George Boston, Wordworks Ltd, (pag.: 23 to 26), Emberton, United Kingdom, 1992

complexes and conurbations, which makes it obvious to recommend that archives should, whenever possible, be housed in areas of low industrial contamination.

For their part, mineral remains (dust) and spores and bacteria of contaminant micro organisms are distributed with similar densities throughout the planet.

Conditioning systems have to be fitted with filters for preventing or at least reducing the entry of harmful gases and micro organisms into the warehouses. The importance and type of filtration systems will depend on the exact locality of the warehouses.

7.33 – Climatic isotropy

The temperature, humidity and cleanness of the air must be kept homogeneous throughout the entire space of the warehouses.

In warehouses conditioned by ventilation, moving the entire air homogeneously represents a very complex problem, the solution to which requires a consideration of the shape of the warehouse itself, the distribution of the shelves and the rest of the obstacles which the air flow can encounter, the characteristics and distribution of the air impellers and extractors and, finally, the physical laws governing the circulation of air, hot or cold, damp or dry.

In warehouses with regular shapes (circular, square or proportionally rectangular) it will be relatively easy to achieve uniform distributions for the air flows. In these warehouses it will also be easier to avoid accumulations of dust.

Shelves and the films themselves constitute obstacles to the flow of the ventilation and contribute towards the formation of "corners" in which the speed of air circulation is reduced or varies, and can even disappear almost entirely. Of course, a film stored in one of these "corners" will be in a very different state of ventilation (and consequently of humidity and temperature) compared to one established for the warehouse as a whole.

The impact produced by the shelves and films can be notably reduced if, when designing and choosing the shelves and their distribution and also the film containers, account is taken of the need to make sure that the ventilation flows are isotropic.

The distribution of air introduction and extraction systems and the height of warehouses and shelves will also exert a decisive influence on homogeneity in the ventilation conditions.

The flow of ventilation currents will always follow the shortest possible path between their inlet and outlet points, and in a poorly designed warehouse there will coexist “corridors" or "columns" of colder or drier air along with "bays" or "pockets" of warmer or damper air.

Simultaneously, the warmer air tends to gather in the upper zones, causing the colder air to descend. So films stored at different heights can in fact find themselves being stored under different conditions.[173]

[173] Controls carried out in the Filmoteca Española [Spanish Film Institute] show that the inside of cans of films stored without artificial climatisation and located at a difference in height of three and a half metres can display temperature differences of up to 1ºC. This type of measurement, made with two thermo-hygrometers at different points of the store, can permit a "map" to be drawn of the isoclimatic

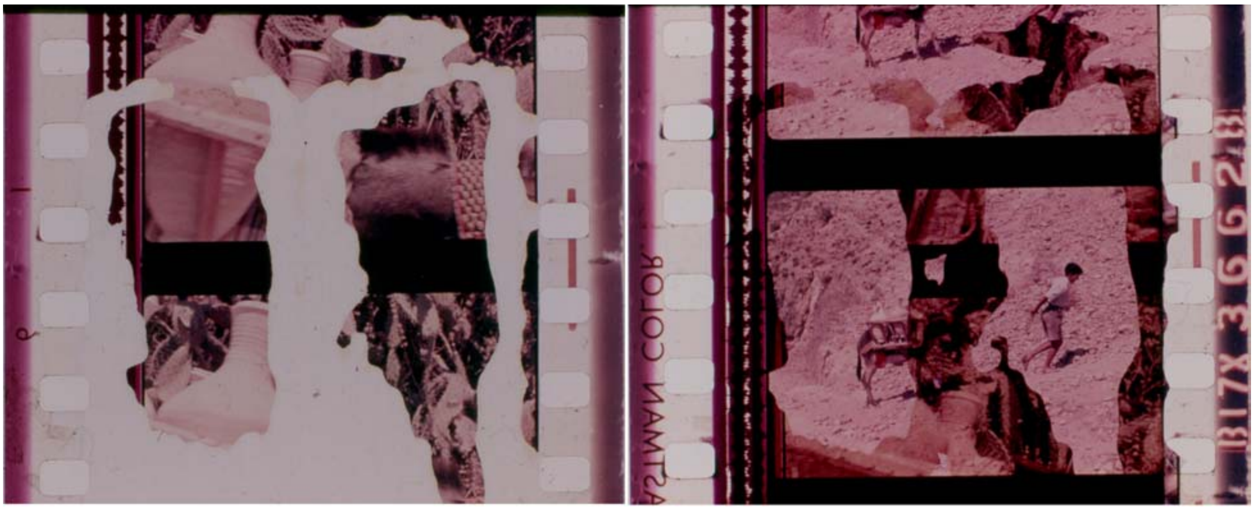
The isotropy of storage conditions is a fundamental question. Throughout this work, the disparity existing among the characteristics of films, even among those characteristics that are theoretically similar, has been stated on numerous occasions. This disparity becomes complicated by the differences existing in the state of conservation of each material and can become absolutely uncontrollable if the real conservation conditions vary from one point of the store to another.

7.4 - Stability at low temperatures and humidities

The need to keep the ambient conditions selected for conservation stable is unanimously mentioned in all proposals for storage conditions, with variation limits being set as narrow as, for example, +/- 2ºC and +/- 5%RH of annual variation recommended in "Preservation of Moving Images and Sound"[174] for colour films.

Considered as one of the foundations of conservation, a discussion of the need for stability can be made by means of two very simple and complementary elements:

- The guidelines contained in conservation proposals are set down starting from the criterion that the materials will be located under certain conditions of humidity and temperature and will remain in them during the entire length of time they are stored. If the conditions vary, if the storage is not prepared for keeping the values of humidity and temperature stable, then the data on which the proposal was founded lose all their value.[175]



F. 168
The change from a wet to a dry atmosphere, damaged the adherent substratum, making easier the desprendimiento of important areas of emulsion that stayed adhered to the support of the next convolution.

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characteristics of the store, which would help to correct deficiencies in conditioning and to conserve the films better.

[174] See reference in Note 20.

[175] The impact on conservation implied by each day's stay outside the archive has been studied – for new photographic materials – by M.H. McCormick-Goodhart and M.F. Macklenburg, in: "Cold Storage Environments for Photographic Materials". The Society for Imaging Science and Technology, 46th Annual Conference, Springfield, USA, 1993. (Cited via Standard ISO 18911)

- There exists a very close interrelation between the ambient conditions in which the materials are conserved and the humidity content (and other characteristics) of the materials; the adaptation of the materials to changes in the ambient conditions is a very delicate process and can result in damage to the material if it is not done under controlled conditions.
When defining the stability conditions that ought to be achieved for the conservation of the materials, there are two premises that need to be considered:

- The films are conserved for use and in all cases, even in preservation materials destined exclusively for obtaining new duplicates, the use of the material will imply a complete change in its conservation conditions.
- This change will be more profound the stricter the conditions are (colder and drier) under which the films are being stored.

Starting from these premises, the stability can be studied via a triple interrelation.

- Interrelation between the outside environment and the storage environment.
- Interrelation between the storage environment and the film.
- Interrelation between the materials constituting the film.

7.41 - Interrelation between the outside environment and the storage
In the climatic functioning of a store, the critical element is, of course, the outside environment. Archives located in very warm, humid or contaminated areas represent very different problems to those of cold, dry and clean areas, and between these two extreme points there is a wide range of situations and possibilities which can only be considered and settled case by case.

Nevertheless, there exist some elements which can be useful in most situations and which refer to the classification and location of the warehouses and to the use of physical resources for the conditioning.

7.411 – Siteing of the archives
The ideal thing would be for the warehouses to be located in those geographical areas that are cool, dry and uncontaminated; these are especially suitable for conservation but, in most cases, for economic or political reasons, the archives have no possibility of choosing the area for siteing their warehouses.

On some occasions, when the climate of the country or political-administrative area in which the archive is developed permits this, separating the materials according to their frequency of use (see chapter 7) can help to achieve sites more favourable for warehouses intended for preservation materials, thereby making it possible for access materials to remain close to their potential users and solving economic problems or political or social pressures.

If the archives can choose the area for siteing their warehouses, the most important decisions would be directed towards avoiding zones with high ambient contamination and greater humidity.

Even when the stores are established in industrial areas, the study of some ambient elements such the prevailing wind direction can permit important gains in the quality of the air and, consequently, permit a reduction in filtration needs.

Except in countries or areas that are subject to atmospheric currents that are warm and damp and with considerable vertical development, locating the warehouses in the interior, on flat plains at more than 500-600 metres above sea level or in mountainous zones would permit major gains in the reduction of temperatures and humidities.

There are many other problems that can have an influence on the choice of site for the warehouses (zones with high seismic activity, areas lying in the flood zones of rivers or those affected by underground water currents, high tension power lines, etc.), but the importance these problems might have in each case can only be evaluated by the institutions having to suffer from them.

7.42 – Exploiting physical resources[176]

Thermal inertia of masses and depression ventilation are the two physical resources, which can be applied for improving the interrelation between the outside environment and that of the warehouses.

These two resources have limited possibilities. Obtaining temperatures close to zero degrees centigrade or humidity of around 25 or 30% using physical resources will only be possible in sites with very favourable outside environments; but the reduction of temperature and humidity values that can be provided by a sensible use of these resources is extremely important, even in very adverse environments.

Considering an intensive exploitation of the possibilities offered by physical resources for creating colder, drier and more stable warehouses is a particularly important policy for archives which do not have economic stability fully ensured. But it also constitutes a coherent policy for archives, which have their funding firmly ensured.

Using the possibilities offered by physical resources, combining them with mechanical systems of acclimatisation, will not only permit very important economic savings to be made, it could also guarantee the stabilisation of temperatures and humidities within certain acceptable values, even if the acclimatisation equipment or the power supply were to fail completely.

7.421 – Thermal inertia of masses

Although the total quantity of heat that an object can absorb without change of state, as well as the speed with which each material absorbs and transmits heat, are parameters that depend on the actual characteristics of the materials, the quantity of heat that will be needed for raising the temperature of an object is always greater when the mass of that object is greater. This is the foundation of the principle known as thermal inertia of masses.

Bearing this principle in mind, when considering the total mass existing in a warehouse it is necessary to sum the mass of the warehouse itself (its walls,

[176] The concept of "physical resources", which will be used on several occasions during this work, refers to the use of physical laws for the benefit of conservation needs.

ceilings, divisions, etc.) with the mass of the materials it contains. So, in order to increase the temperature by one degree for a warehouse constructed with thick insulating walls and with all its shelves full of films, it would be necessary to introduce many millions of calories into the warehouse. From this point of view, thermal inertia will be increased as much as possible in underground warehouses.

The thermal inertia of masses only provides stability, and, in each case, in order to use this physical resource, other problems will need to be solved. So, for example, an underground warehouse will provide the maximum stability and a very important energy saving in the acclimatisation; but it also makes it necessary to tackle other problems raised by the possible existence of variations in the water table or infiltration of damp. Problems of this type have to be solved by means of waterproofing and drainage systems and by means of constructing separation chambers for isolating the warehouse from the ground.

Some institutions have found quality economic solutions by resorting to the use of railway tunnels, whose humidity conditions were already known and, moreover, if they were constructed with a gradient this can contribute an optimum solution for the ventilation. Disused salt mines have also been resorted to; they can be converted into perfect warehouses for the conservation of documents with just some consolidation work being carried out. In other cases, fortifications or solidly built monuments have been used.

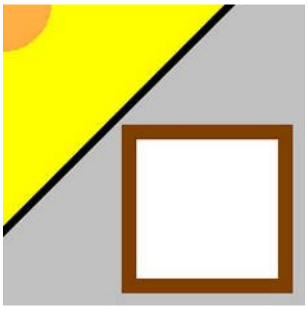
When current technologies are used for building and acclimatising stores, the use of physical resources is necessary for guaranteeing the stability and for reducing energy consumption in the acclimatisation.

The enormous development undergone by plastic materials in the second half of the 20th century led to the appearance of techniques which, by means of the superposition of layers of materials alternating different capacities and speeds of heat absorption and transmission, are able to achieve very high coefficients of thermal insulation with very lightweight partitions: walls of thickness less than 30cm can provide degrees of insulation similar to those reached by others that are a metre thick and constructed with various layers of stone, brick and earth. But these lightweight constructions contribute nothing to the interior thermal stability of the warehouses and consequently they enormously reduce the number of kilocalories necessary to modify the temperature of the materials.

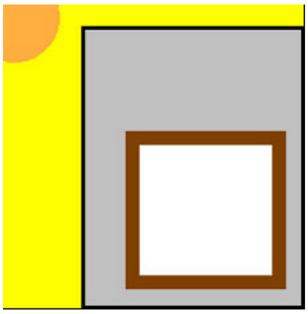
A construction which does not use the thermal inertia of masses will be much more sensitive to the influence of the outside and will depend entirely on the continuous functioning of the acclimatisation equipment.

Heat is transmitted by two methods: conduction and radiation.

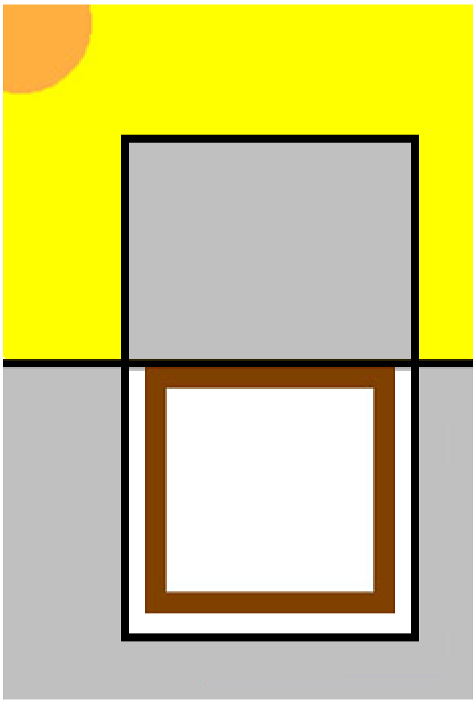
All thermal insulation systems function by different mechanisms, such as mass accumulation or use of materials with various heat absorption or transmission coefficients – including air chambers – which achieve the reduction of transmission by conduction. But, naturally, in the construction of a warehouse, the main contribution that may be made to the thermal insulation is by preventing the air from heating, and this means preventing the direct incidence of solar radiation.



In order to insulate a building from solar radiation, one can use something as simple as a sunshade which keep the building in its shadow, reflecting or absorbing the major part of radiation and using the air mass between the sunshade and the building to disperse the heat; so it would combine the mechanisms of dissemination and ventilation by way of difference of pressure.



When installing a warehouse inside a building, it works as a shield, cutting out the arrival of solar radiation to the warehouse. In such cases, the shield solves the problem of disseminating the heat it receives, preventing it reaching the warehouse; it will also be necessary to avoid the problems of the building itself (security, leaks, etc.) which work against the warehouse.



In underground construction the terrain itself will take care of stopping the radiation that reaches its surface and disseminate the heat throughout its whole mass; but in adopting this solution it will be necessary that previous systems be capable of eliminating risks of humidity which can derive from variations in the freatic level of the terrain.

But the effects of thermal inertia don't stop the insulation. A film wound will take a longer time to heat up than the same quantity of separate and unwound film, and this follows other criteria, complementary with the previous ones, of the volume/surface relationship.

A body loses or absorbs heat throughout its surface, and according to the amount of heat it loses or gains through its surface, the rest of its mass changes its temperature, either increasing or decreasing .

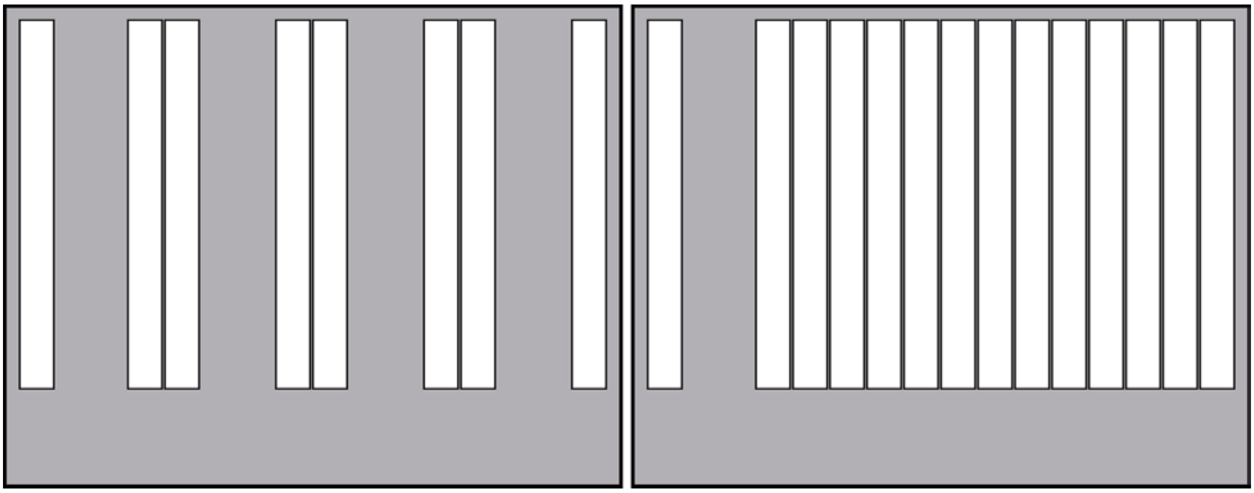
For a determined volume, a sphere represents the smallest possible surface. A sphere of a mass of one kg will take an infinitely longer time to change its temperature than a very thin sheet of the same material.

Of course, it is not possible to build spherical warehouses for the films and the height/surface relationship often makes the use of cubic volumes impossible but, in order to reduce the negative relationship between the increase of the surface and the heat transmission to a bare minimum, it is necessary to try to achieve warehouses which are constructed on the squarest possible floor.

Physical resources can also be applied in the interior of the warehouses in order to increase the thermal stability.

A warehouse with compactable mobile shelves will have 40% more capacity than another with open shelves. This increase in capacity will mean a direct saving by permitting the use of warehouses with smaller constructed floor space in which the total volume to acclimatise will also have been reduced by 40%. But not only the dimensions of the warehouse will have been reduced; compactable shelves full of films will also increase the density of the store, improving its thermal stability and once again reducing the cooling power needed to keep its temperature conditions stable.

Combining the effect of the inertia of masses with the use of materials with different thermal conductivity and with protection elements against solar radiation, it becomes possible to achieve much more stable and more economic and sustainable warehouses. Mankind has used these systems throughout the ages and, properly combined with the rest of the existing systems and bearing in mind the needs of the archives, they present advantages that can be decisive for the conservation of films.



F. 172
In a warehouse of 38,5m²,1680 cans of 600 meters with a weight of 8.400 fg can be preserved in opened shelves, and 2940 cans with a weight of 14.700 kg, can be preserved in compact shelves: 43% more.

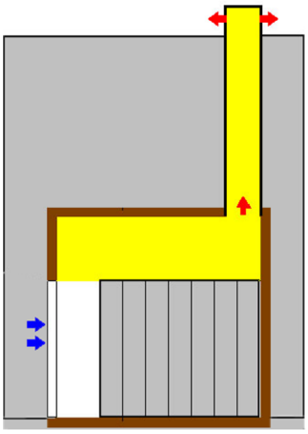
7.422 – Depression ventilation

Although much less familiar than the thermal inertia of masses, ventilation by pressure differences also constitutes a resource that has historically been used by humanity for cooling and dehumidifying its buildings.

As is known, when air is heated it expands and becomes lighter in terms of unit volume. Consequently, hot air tends to rise seeking zones of lower pressure higher up. The effects of this rising movement (small but absolutely unstoppable) can be observed even in such low heights as that of a room.

But in reality, depression ventilation works on a principle much more powerful and independent of temperature. Bearing this principle in mind, in a building which has its air inlet at a lower level and its outlet at an upper one, the entire interior of it will act as a duct linking two zones of different atmospheric pressure (in other words, as a communicating vessel) via which the air will continually circulate, rising through the interior of the building in order to try to equalise the two pressures without ever managing to do so.

This effect, which will scarcely be perceptible in a room, would become a hurricane force jet of wind if the air current had to travel through the interior shaft of a large skyscraper.



Combining these two principles (the tendency of hot air to rise and the general tendency of air to flow towards a zone of lower pressure when it circulates through a duct), it becomes possible to achieve very considerable reductions in temperatures and humidities and, something that is even more important, these reductions are independent of any failure in the functioning of equipment or the power supply, or problems in the financing of the archive.

7.43 - Interrelation between the environment of the storage and the film

Although in general, when talking about the environment in which the conservation is carried out, this refers to the environment of the warehouses, in fact the films are located inside containers (cans or bags) which modify the ambient conditions of conservation[177].

This type of situation, in which the materials are located in containers which are in turn located inside the conservation warehouses, is of the type described as "one box inside another box ". In this environment, the ambient conditions established for the whole warehouse can be conceived as macroclimatic conditions, while the interrelation between the environment of the warehouse and the film becomes confined to the scope of the microclimatic conditions existing in the interior of the containers.

When talking about the characteristics of the microclimate existing in the interior of the containers, it is necessary to consider the possible interaction between the containers themselves and the film and, moreover, to think about the ventilation conditions existing inside the containers.

In relation to the interior ventilation of the containers, two types of proposal have been developed which, in practice, constitute absolutely different

[177] A study conducted in the Filmoteca Española [Spanish Film Institute] showed that inside boxes filled with film the variations in temperature and humidity that took place over a week were reduced by more than 50% compared to those registered in the store; with the maximum temperature variation recorded amounting to less than 1ºC.

conservation strategies: conservation in ventilated cans and conservation in hermetically sealed containers.

7.431 - Interaction between the container and the film

The use of boxes for the transport and conservation of reels of film is a practice as old as the motion picture industry itself.

A reel of film is a relatively delicate object for which a box can provide a reasonable degree of protection against dust and knocks, and against contact with dirty or unsuitable materials, which could cause physical damage to the material. Parallel with this, a box can also be an opaque receptacle that protects the film from light, thereby avoiding the degradating action of ultraviolet radiation.

For many years, the boxes used were constructed from sheets of glued cardboard or from metal plate folded and welded or pressed. Cardboard boxes disappeared due to the increase in the length of the reels[178].

The use of plastic materials in boxes first started for 8 and 16mm reversal films and later on, for economic reasons, many distributors adopted the plastic container for their prints.

For economic reasons, the reuse of containers is a very widespread practice.

Laboratories usually deliver processed materials in the same container that the raw stock was delivered in and few archives are able to replace these containers on the arrival of each new film.

Although distribution companies still frequently use the containers in which they have received the copies (by simply superimposing a new label with their own commercial identifications), they also frequently change the container, using new boxes printed with their own brand names.

Each reel is generally packed in a box. In 16mm release prints, boxes capable of holding the two or three reels of each film used to be frequent.

For many years, after processing each reel, the laboratories used to give it a paper wrapping in order to protect it from dust and micro-damage until its delivery to the client. In professional filmmaking, the paper wrappings were to become replaced by plastic bags.

This technique of wrapping in paper is also used in the process of cutting the negative, the separate reels of each take being wrapped in fine paper with the footage number of the takes being written on that wrapping.

The possible negative interaction between the material of the containers and the conservation of the films has never been taken much into consideration by industry and, until the arrival of current distribution systems[179], resistance to impact was the only quality that was sometimes demanded of containers for copies.

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[178] Even if in some countries they have a general use, paper or cardboard containers have continued to be used for copies of short footage in 8 and 16mm format, as well as for photographic negatives, rolls of microfilm and similar.

[179] These systems – based on mass publicity launches and the simultaneous release of the film in virtually the entire market – have converted copies into products for immediate consumption and have done away with the need for containers to provide good resistance against impact.

Michelle Edge, working in the Polytechnic University of Manchester, conducted an important experimental study to determine the possible interactions between the material of the containers and the stability of the films[180].

Using accelerated aging techniques on samples of triacetate film (with and without emulsion) conserved between sheets of glass, of polyethylene, steel galvanised with zinc, and aluminium, M. Edge comparing the loss of viscosity of the polymer chains, manages to make conservation predictions (by means of the Arrhenius transformation) for conditions of 21ºC and 50%RH.

The results showed that the degradating interaction was less when the sample was in contact with a chemically inert material such as glass, a situation in which a durability expectation of 110 years was obtained. The durability prediction fell to almost half that (60 years) in contact with polyethylene, fell again with aluminium (50 years) and reached its minimum, 35 years, in samples placed between sheets of steel.

This study confirmed the importance of the role that metal ions can play as catalysts of degradation and highlighted the importance of using plastics as containers.

Later studies recommend the exclusive use of containers made of polyester (polyethyleneterephthalate), polystyrene, polyethylene or polypropylene.

These materials can be used mixed with hardeners such as talc, or with the addition of mineral fibres to give the containers greater mechanical strength.

Plastics derived from cellulose and chlorate plastics (PVC) can be harmful for conservation, as can containers made of glued cardboard for films in reels.

The paper wrapping mentioned in an earlier paragraph are not suitable for conservation (even when porous or non-acid papers are used) due to the facility for absorbing humidity characterising these materials.

F. 174
This film fragment, used as a bookmark for many years, makes clear the interaction between paper and film (the part of film situated in the book was gravely damaged by the sulfuration produced by the acidity of the paper), nevertheless, it is necessary to consider the influence of the mass in these interactions: a paper sheet inside a can full of film, won't have enough mass to affect chemically the film.

180 Michelle Edge: "The Deterioration of Polymers in Audio-Visual Materials". In "Archiving the Audio-Visual Heritage". Third Joint Technical Symposium. Technical Coordinating Committee and UNESCO; Ed.: George Boston, Wordworks Ltd, Emberton, United Kingdom, 1992.

The design of the containers can also be important for conservation.

The existence of a central spigot, located in the centre of the lower half of the can will locate the position of the core the film is wound on to be fixed; thereby avoiding movement and rubbing that would damage the material during transport.

In 16mm and sub-standard gauge films, above all, the reels can be an essential element for projection but they are not a suitable element for preservation of the material, even in copies intended for projection if these are going to be kept in storage for years without being used at all (a very common situation in archives). The gaps existing in the sides of the reels produce differences in the ventilation of the convolutions of wound film and, after some years, these differences reveal themselves in deformations, perceptible to the naked eye, which will endanger the film when it comes to be used again.

7.432 - Conservation in ventilated containers

As mentioned earlier, ventilation is necessary for removing the gases produced by the chemical degradation of the material and for reducing the conditions favourable for the development of micro-organisms.

In this process, the containers, the boxes, bags and reels, constitute the last and perhaps the most effective obstacle for ventilation of the materials. Of course, the entire ventilation system created for the stores will be absolutely useless if the action of the containers prevents ventilation of the microclimate in which the films are really being stored.

In spite of its apparent difficulty, achieving an adequate flow in the air replacement inside closed tins does not represent a complex problem.

If the containers are provided with three or more holes (of diameter no greater than 10mm) symmetrically distributed along its sides, the pressure differences between the inside of the can and the warehouse will – and very efficiently so – take care of the replacement of the air inside the can.

Due to pressure levelling mechanisms:

- Any quantity of gas produced by degradation of the film will create an increase in the pressure inside the can, which will be compensated with the immediate exit of an identical quantity of air to the outside.
- Equally, any temperature difference will lead to a difference in pressure and to an exchange of air from the inside to the outside or vice versa.
- Finally, the pressure levelling mechanism will also function in the case of any difference in specific humidities existing inside the boxes and in the warehouse.

The combination of these three physical mechanisms will ensure ventilation.

From this point of view, the plastic bags used for protecting the film from dust and from handling during transport should not be used for conservation. A plastic bag is a highly efficient element of protection for transporting the film but it can become a hermetic receptacle preventing the circulation of air.

Achieving isotropy in the ventilation of the film can be much more difficult.

The central spigot mentioned in the previous chapter can be a very important element because it keeps the film centred and the air chamber separating the perimeter of the reel from the container will therefore be symmetrical..

But as far as the two surfaces of the reel are concerned, the situation is much more complicated. While the lower face of the convolutions will remain resting on the box, the upper face will be located beneath the layer of air (a few millimetres in height) separating it from the lid of the container, and under these conditions, the ventilation will be completely different for the two edges of the film, and this can lead to the deformation of the film.

To solve this problem, one can use containers with a base that has been moulded in the form of a relief (with a granular design or with radial arms or convolutions), which will create a "chamber" of air underneath the reel of film[181].

Nevertheless, when considering very long-term conservation, the most complex problem lies in ensuring the exit of gases from inside the convolutions. As stated in chapter 6 when talking conservation of films in rolls, in a reel that has become shrunk, the pressure between successive convolutions increases, causing the space between one convolution and the next to become hermetically sealed and preventing the exit of gases.

Solving that problem involves controlling the tension of the winding reducing it to just a sufficient level for permitting the reel to be moved to the box and for rewinding the film each time it is inspected or used, in order to completely eliminate pressure increases.

If conservation is carried out at low levels of relative humidity, the loss of humidity of the emulsions will lead to a decrease in their thickness, producing a drop in the winding tension, which can be sufficient for guaranteeing ventilation between convolutions.

In nitrate materials (which are the ones that undergo the greatest contractions) it can also be very effective to withdraw the core after winding and before introducing the film into the container. This system will enable the film to compensate for its loss of length, sliding and modifying the position of the winding and preventing an increase in pressure between convolutions. [182]

7.433 - Conservation in hermetic containers

Conservation systems in hermetically sealed containers arose from the search for satisfactory economic solutions to proposals for conservation in very cold and dry atmospheres.

As stated earlier, control over the condition of relative humidity in the warehouses is the component that most increases the cost of the facilities and their maintenance. This increase will be progressively more important the lower the proposed temperatures are.

In virtually all possible locations, in order to achieve artificial acclimatisation of a warehouse, it will be necessary to have equipment capable of cooling or

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[181] Nowadays there also exist plastic elements (grilles) which can be placed in the bottom of the cans to produce the same effect.

[182] In order to perform this technique it is essential to protect the material, placing a certain length of free film in contact with the core at the start of the winding which will come out with the core when the latter is withdrawn.

heating or drying or humidifying the air, depending on the requirements of outside conditions at each moment.[183]

In order to achieve a stable store at 21ºC and 30%RH, conditioned air will need to be introduced at about 13º and 50%RH, which are parameters that can be achieved with conventional systems of artificial acclimatisation.

For temperatures of the order of 7ºC or lower, the technologies created for cold chambers can provide economical and satisfactory results, provided no attempt is made to control the relative humidity. If the aim is to achieve stable conditions in situations of the type 5ºC and 30%RH, then the air ought to be introduced at temperatures close to 0ºC and at a maximum of 45%RH and, of course, for warehouses in freezing conditions (for example: at -5ºC and 30%RH) much more rigorous treatment will be needed.

In the field of conventional acclimatisation and within the usual parameters (for example, offices), cooling and dehumidifying are part of a single process and, in fact, it is very often necessary to insert systems for rehumidifying the cooled air.

When considering humidity conditions of around 30% or, of course, temperatures close to or below zero degrees, it will be necessary to use systems specifically designed for dehumidification of the air.

In order to reduce the humidity there are two types of system: the first heats the air in order to extract the humidity and then cools it down again prior to driving it to the warehouses; in the second, the drying takes place by chemical adsorption, with the flow of cooled air being brought into contract with a cold dry desiccating agent, of the silica gel type.

In both systems, the energy consumption needed for carrying out the heating, drying and recoiling of the air, or for cooling and drying the desiccating agent again, represents a major part of the total energy consumption. Even so, the energy consumption of adsorption systems (which can be the only truly efficient systems under extreme conditions) is less than heating systems.

The "sealed containers" system tackles this difficult problem by separating the systems used for control of the temperature and of the humidity: the temperature is controlled at the macroclimatic level, corresponding to the warehouses, while the humidity is controlled at the microclimatic situation of the interior of the containers.

In this solution, the film is packaged under a controlled situation in which the water vapour content of the air remains at a previously defined level. So, once the container has been hermetically sealed, and even though the temperature of the container and film is lowered, the air retained inside the container will not be able to increase its relative humidity beyond that permitted by the water vapour (specific humidity) it contains.

In order to conserve a film in a hermetically sealed container, it is essential to solve the problem created by the gases produced by the chemical degradation of the material, for this problem, two different strategies have been developed:

- Storage under freezing

[183] In the discussion of these concepts, use is again made of data provided by P. Ezquerra in his speech in the ARCHIMEDIA Seminar held in Madrid in January 2002.

- Utilisation of absorbent elements

7.433.1 – Storage under freezing

This strategy aims to reduce the speed of chemical reactions of degradation by storing the materials under conditions of freezing. The degradation reactions can reach the point of being halted if all the components of the film are brought to below their freezing point.[184]

Herbert Volkmann, ex-director of the Berlin Filmarchiv, describes the two packaging variants that have been used in this type of conservation.[185]

In the first, widely used in German archives for films with colour emulsions, the conditioning is carried out in an acclimatised room under conditions of temperature and humidity that has been selected for the storage (for example, -5ºC and 30%RH)[186]. Each reel of film must remain in the acclimatisation room for several days. The packaging will be done in the same acclimatised room, with the film being introduced into a box which will be sealed with self-adhesive, waterproof plastic tape.

In the second variant, developed by the Swedish Film Institute and known as FICA (Film Conditioning Apparatus)[187], the films are introduced into a large cupboard, acclimatised at 20ºC and 20-25%RH, where they remain for between one and two weeks until their humidity reaches equilibrium with the ambient humidity. Weighing the film, which can lose up to 1.5% of its weight, can monitor the progress of the dehumidification process of the material. Once the conditioning of the humidity is concluded, the reels are successively introduced into two bags made of aluminium and plastic sheets, from which the air will be extracted until a partial vacuum is produced and which will be thermo sealed in order to guarantee air tightness.

In both variants, following the acclimatisation the packaged films are taken to cold storage chambers which, as stated earlier, will not need to have complicated systems for humidity control.

Clearly, eliminating the need to control the humidity will represent a major economic saving, both in the construction of chambers and in their energy consumption. In the two procedures described here, the duration of the conditioning treatment, which has to be done reel-by-reel, constitutes a practical problem and implies a considerable economic investment.

In spite of the work represented by reel-by-reel acclimatisation of films, if conservation by freezing is being considered, then "sealed container" procedures might be the only solution. As stated by D. Walsh in the quoted article, when talking about situations of even - 20ºC, with relative humidity of around 20-30%, there exist no technical solutions that can indefinitely guarantee

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[184] For example, acetic acid freezes at -17ºC.

[185] Herbert Volkmann: "The preservation of dyes in developed color films". In: "Preservation and restoration of moving images and sound" - Chapter 5. FIAF, Brussels, 1986.

[186] The conditioning treatment can be done under other conditions of temperature or humidity, always provided that the total humidity content in the atmosphere is compatible with the percentage of relative humidity which ought to be maintained in the storage.

[187] The description of this system has followed the presentation: "Cold Storage using the FICA Apparatus", made by David Walsh in "The Joint Technical Symposium, The challenges of the 3er Millenium". CST / CNC, Paris, 2000.

the correct functioning of the acclimatization devices, if they must use simultaneously humidity and temperatures.

It is not possible predict what the consequences could be of defrosting if, for example, a complete failure were to occur in the power supply. In theory, the FICA vacuum-sealed bags system will permit – almost without any variation at all – the humidity conditions to be conserved, but if the rise in temperature were to initiate (or reinitiate, as the case might be) a degradation process, the gases emitted would find an ideal condition (vacuum) for performing their role as catalysts/accelerators of degradation.

7.433.2 - Utilisation of absorbent elements

Other systems use absorbent materials for controlling the humidity or removing gases produced by degradation.

As far back as the end of the thirties, it was proposed to place small bags containing a silica gel type material inside the containers of raw film stock. This system has been widely used for films intended for particular uses, such as microfilming, and for the preservation of new photographic equipment.

Silica gels are materials with a large capacity for absorbing moisture. Bags containing silica gel are usually provided with an indicator patch that changes colour in order to show the degree of saturation reached by the desiccant. When the desiccant has become saturated with humidity it can be processed by means of heating in order to reactivate it, after which it can then be reused.

This material is also used for the conservation of processed films, in which case the critical point lies in calculating the amount of absorbent which must be placed in each can in order to achieve equilibrium of humidity in the ambient interior of the container without affecting the film. In "The Book of Film Care[188]", Kodak mentions a conservation system based on dehumidification treatment by means of silica gel packs arranged in cans or in special cupboards.

In 1992, Dr. Tulsi Ram[189] presented some studies made by Kodak on the use of zeolite crystals for the absorption of gases produced by degradation.

Zeolite (sodium aluminium-silicate) has a moisture absorption capacity far higher than silica gel and, moreover, by selecting the crystal sizes, it can become a “trap” capable of filtering molecules of predetermined sizes.

The use of semi-permeable bags containing small quantities of zeolites is very effective for conditioning the humidity inside the cans and for absorbing materials such as acetic acid and other degradation products. Studies of accelerated aging conducted by the Image Permanence Institute[190], show how a film, conserved in a sealed can at 21°C and 50%RH and protected with 5% by its weight of zeolite bags, would triple its durability expectations.

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[188] "The Book of Film Care. Appendix D - Method of Desiccating Film". Kodak Publication, N° H-23. Rochester, New York, U.S.A., 1983. On the use of silica gel for preservation, see also the text by D. Walsh mentioned in the previous chapter.

[189] Tulsi Ram: "Molecular Sieves and the Prevention of the Vinegar Syndrome". Paper presented at 1992 AMIA Conference.

[190] J.L. Bigourdan and J.M. Reilly (Image Permanence Institute): "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome: Preservation Strategies for Acetate Base Motion-Picture Film Collections". In: Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000. Pp. 14 to 34.

The conserving effectiveness of both materials depends on the accuracy with which the amount of absorbent material which must be placed in each container is calculated (as a function of the weight of the film) and on the frequency with which the absorbent material has to be renovated and regenerated.

7.44 - Interrelation between the constituent elements of the film

As has been stated on numerous occasions, the degradation of one of the components of the film can produce even more serious and immediate effects on the other components. So, for example, in a film whose base is in an initial state of degradation, without yet showing any decay in its physical characteristics, the acetic acid produced by the degradation will already be accelerating the fading of the dyes.[191]

The equilibrium of humidities between emulsion and base can have importance for the conservation of films.

D. Walsh states that, during conditioning in the FICA chambers at 20% relative humidity, the film can lose up to 1.5% of its weight, an amount which coincides almost exactly with the average humidity content in the emulsions of processed and used films. Consequently, when considering the use of ambient conditions for conservation, it is also necessary to consider the effects that can result from these systems altering – as they will undoubtedly do – the equilibrium of humidities existing among the materials making up each film.

The emulsions release and absorb humidity with much greater facility and avidity than do the bases, as revealed by the fact that the direction in which the transverse curving of the film takes place (on the emulsion or on the base) depends on whether the emulsion loses or gains humidity[192].

The existence of humidity transfers between bases and emulsions was revealed during the course of research into acetic degradation, when studying the results of analysis conducted on films shot between 1955 and 1990.

When compiling the data obtained in the series of analysis, it was observed that, inexplicably, films prior to 1978 displayed less acidity than more modern ones, and that this grouping corresponded to that presented by other series of data, such as the total humidity content in the film, the distribution of humidity between emulsion and base, and the tensile strength.

This grouping of experimental results could be related to the history of the conservation of the films forming the origin of the samples used.

Up to 1987, films prior to 1978 (negative trims) had been located in a somewhat damp store, and were then transferred to another stable and dry store. The more modern samples (protection leaders of negative duplicates) came from films which had been in a single warehouse, stable and dry, since they were shot.

In the following reasoning, it was considered that the oldest films had absorbed humidity in the original warehouse (damper), which would explain their high total humidity content. The change of the films to the drier store

[191] In this regard, see the study presented by Tulsi Ram quoted in the previous chapter.

[192] This curving mechanism was used by Tulsi Ram to control the effectiveness of zeolite as a moisture absorbent.

initiated a drop in the humidity content, a process that was faster and reached greater importance in the emulsions.

The combination of the two circumstances described above would explain the fact that the bases had greater humidity and the emulsions less humidity than the samples coming from the other warehouse and those studies in later stages of the research.

So, it was possible to raise a hypothesis, perhaps valid, on the irregularity detected in the acidity of the samples.

The low acidity of the older samples possibly took place via two movements, the second of which would be directly related to the change in the humidity conditions. In the first movement, part of the acetic acid produced over the years migrated towards the emulsion and remained there; later on, with the change in storage conditions, the acetic acid existing in the emulsion was dragged to the drier ambience of the outside (along with the humidity lacking in the emulsions).

The reasoning stated here can only be regarded as a hypothesis but there is no doubt that it shows that the change of store affected the equilibrium of the humidity between emulsion and base in the films.

There does not exist any specific studies on the importance which the exchange of humidities might have between emulsions and bases, though the effects of these changes can evidently be developed in all directions and reach the point of constituting a problem for conservation. This is one of the risks which archives have to accept.

Studies conducted in laboratories (which are the only places allowing predictions to be made on the behaviour of materials under different conservation conditions) unequivocally point to the fact that conservation in low conditions of relative humidity constitutes an important and safe contribution to the preservation of materials and, very notably, for chromogenic emulsions.

Nevertheless, in the empirical knowledge of archivists there is a wide-ranging list of examples of situations in which humidity has not been the determining factor for degradation, situations ranging from specific cases, such as triacetate films "conserved" for many years in conditions of extreme humidity and which have not been affected by any acetic degradation, up to the current situation of negatives and positives which have always been in the same warehouse and yet, nevertheless, they display differences in the fading of colour.

These observations, derived from first-hand experience, do not affect the general principle of conservation in cold dry conditions but, once again, they show that the conservation of the cinematographic heritage is a highly complex process for which there exist no single solutions that are universally valid.

7.5 – Acclimatisation and reclimatisation

The acclimatisation treatments for the storage that have been described for freeze storage in sealed containers are essential because, in these procedures, the temperature and humidity control is done in separate environments. But the acclimatization of the materials in the warehouses (that the materials adapt their temperature and humidity levels to that of the warehouses) is an unavoidable process which, in theory, if ventilated (or non-sealed) containers are used, will not require any work being carried out and which, depending on the conditions established in each store, might last for days, weeks or months.

Special procedures for the introduction of materials into the warehouses are necessary in order to make sure that they are acclimatised under controlled conditions and to make sure that it is carried out over periods of time that are acceptable for the functioning of the archives.

When the differences between the entrance conditions of the material and those existing in the stores are very pronounced, then it will be necessary to follow a certain pattern for acclimatisation of the materials.

So, for example, the introduction of materials that are under standard conditions (50%RH) in a warehouse at 30%RH can cause a very sudden break in the humidity equilibrium between the emulsion and base, a break which, combined with a sharp change in temperature, can also damage the adherent substrate and weaken the bond between emulsion and base.

In those situations, for daily deliveries into the warehouses, a controlled humidity chamber is going to be needed to regulate the conditions, and stagger the change in conditions of the materials.

Considering that the last stage in the conditioning will always be in the store itself, for archives in which the use is considered of electro-mechanical acclimatization systems, it will not be a complex problem to construct a chamber permitting the staggering, in two or three stages, of the conditioning of the films.

When the conservation is under cold dry conditions, in order to reacclimatise the films to the conditions of use, there are two problems which have to be overcome: avoiding the formation of water condensation on the film or its container and making sure that the equalising of the humidity between film and outside atmosphere and between emulsion and base does not have any adverse consequences for conservation.

The first of these problems derives from a mechanism that is the opposite to, though symmetric with, producing the increase in relative humidity when the temperature drops, and which was remarked upon earlier.

In reclimatisation, if the specific humidity is kept constant while the temperature is raised, the fall in relative humidity will take place via condensation of part of the water vapour, thus reducing the amount of vapour present in the air and maintaining the partial pressure of the vapour in equilibrium.

At this point, the thermal inertia of masses will act against the film. The air (since it has less mass) will heat up much quicker than the film or its container, and the water vapour will tend to condense (as dew) on cold polished surfaces; for example, on the surface of the film.

When the conservation is done in the hermetically sealed bags of the FICA system, then this problem does not exist. The minimum quantity of air that was able to enter the bags does not constitute any danger at all.

By using this conservation system, it is only necessary to delay opening the two bags until the temperature of the film has reached that of the ambient atmosphere.

When the conservation is carried out in boxes, whether sealed or ventilated, the reclimatisation must be in a chamber with controlled humidity and temperature, and the conditioning will be carried out in two phases: increasing the temperature and increasing the relative humidity.

The temperature must rise slowly, from a situation identical to that of the warehouse up to that of the external atmosphere. Herbert Volkmann, based on the experiences of the Filmarchiv, states that a 35mm film conserved at -5ºC can be brought up to the right temperature in about six hours. On the other hand, Kodak, in its recommendations of use for raw stock (vacuum conserved), states that 72 hours might be needed for acclimatizing it from temperatures less than -20ºC.

In order to avoid condensation of humidity on the film, during the temperature raising process the chamber must remain in a relative humidity below that of the warehouse. In that situation, the film will release any humidity to the dry air while it is warming up, thereby avoiding the formation of condensation on its surface.

The duration of the rehumidification process must be determined empirically in accordance with the specifications of the chambers, though it is obvious to point out that this new release of humidity from the film cannot be maintained for very long. So, the rise in humidity in the chamber should already have begun during the last stage of warming.

No matter which systems have been used for the conservation and for the reclimatisation of the film, once it leaves the chamber the humidity absorption process will last for several days or even weeks or months. This is a very important circumstance which will need to be considered with scheduling the use of the materials.

Of course, exposing a poorly humidified film to the sudden heat of a film gate will involve a risk that is difficult to accept.

8 - Classification of materials for conservation

Classifying the materials for conservation means sorting them into groups of materials that will require the same storage conditions. Yet, as the number of storage conditions that it is possible to establish in the warehouses are not infinite, in these classifications each grouping has to take in many different types of material.

When establishing the criteria for the grouping, it is first necessary to recogognise the uses that can be presumed of each material, both on account of their importance for the preservation of the original characteristics of the works and on account of the needs of each archive in line with its own objectives.

Although both necessities, the preservation of the motion picture works as a part of the Cultural Heritage and the functioning of archives, have to be regarded as equally important, they can also present very contradictory aspects. The conservation of heritage must always be considered as the prime objective, but it is not possible to ignore the structural weaknesses and the necessities which the archives might have in each era. Those who categorically state that archives must work for the future... are liable to find that the future never arrives.

Secondly, it has to be borne in mind that each film is not formed of a single material but instead composed of a set of different materials, whose characteristics and conservation needs can even be contradictory.

Although in principle, and to establish these criteria, separate consideration has to be given to each of the components with special attention being paid to the conservation needs of the component displaying the worst stability characteristics, it is also necessary to bear in mind the possible existence of active degradation processes in the materials, the possible negative interactions of their components and the processing and treatments (tinting, varnishing, polishing, etc.) which each film might have undergone.

Following the two criteria stated, when establishing a classification for materials one will also be defining the conservation conditions that ought to exist in the warehouses; in other words, one will in some way be establishing a classification for the warehouses.

Different institutions, research centres and film archives have issued recommendations or published their experiences on conservation conditions for each type of material, and numerous aspects of these recommendations are contained in this work but, as will be stated more fully later on in the section on three-layer emulsions of chromogenic systems, the aim has also been to include aspects that relate film conservation with the evolution of the motion picture industry and with the economic and technical possibilities of the archives. For this reason, the recommendations on conservation conditions included in this chapter are developed in a series of levels (up to six in the case of chromogenic emulsions), which will result in different durabilities for the materials.

8.1 - Classification by use of material.

Paragraph 5.5 of section two of this work presents a classification of materials in line with the technical, administrative and conservation circumstances affecting their use. It is now necessary to relate the expected frequency of use for each material with the deterioration that could result from the type of use for which it is destined and with those that could occur due to changes in the conditions of humidity and temperature undergone by the materials.

In reality, given that attention will only have to be paid to the frequency of use, this is an extremely simple classification.

If, in a cinematographic archive conserving materials of all types, a grouping of materials were to be made regarding the uses for which they are reserved, then three levels of use could be defined:

- **Minimum use**

Basic materials for the conservation of the film.

These are materials which only leave the warehouses for use as originals, as elements for checking in the making of new copies or for other work directly related to the preservation or restoration of the film to which they belong.

A.- Original negatives.

B.- Duplicate positives for preservation.

C.- Duplicate negatives, when Duplicate positives for preservation do not exist

D.- Projection prints, when they are the earliest generation material conserved of a film or when they have been obtained from the first release of the film.

E.- Other materials conserving information on the making of the film or on the photographic or sound characteristics connected with the original release.

- **Low use**

Duplicates for use in reproduction or prints of special quality or for low-level use.

These are materials destined for the normal use of the motion picture industry; they are materials whose deterioration due to use is already expected and which are not fundamental for the preservation of the film; but they are materials which, due to their scarce frequency of use and because it is possible to control the quality and care with which they will be used, have certain relatively high durability expectations.

F.- Duplicates Negatives destined for the production of new copies, when the positive safety duplicate from which they were obtained has been conserved, or any other duplicate positive or negative of proven quality.

G.- Top quality projection prints, which are not necessary for preservation of the work and which are only used for special and highly controlled projection. Equally, prints classified as "reserve prints" due to the existence of others in use, plus those belonging to films for which there is a very low demand and which can remain in storage for some years without being used.

- **Access materials**

H.- Prints destined for public access or for collections.

Making a classification of this type enables the maximum efforts to be focused on the preservation materials, in addition to:

- By separating out preservation materials, this reduces the physical dimensions of archives requiring greater stability and it facilitates the preparation of protocols and systems for deposit and removal acclimatisation, divided into those for preservation materials and those for reproduction or access.

- By separating out the access materials, in order to conserve them under less strict conditions, the "adaptation shock" which they must overcome when leaving the warehouse in order to rebalance their humidity levels is reduced, and a reduction is achieved in the efforts and investments aimed at the conservation of materials which, on account of their characteristics or their conditions of use, are destined for a short "life".

Following this classification, there will be maximum stability warehouses, high stability warehouses and use warehouses, in each of which the conditions of humidity and temperature considered appropriate would be established (within the economic budgets of institutions).

8.2 – Heeding the characteristics of the components

Films that are conserved in archives are made up of many different materials: plastics, gelatines or resins, silver, dyes, varnishes and ferromagnetic oxides or metals.

The classification proposals made considering the characteristics of these materials must also consider the needs of the most unstable component and the influence of the rest.

8.21 – Varnishing and "polishing" treatments

"Polishing" treatments with solvent used for "restoring" the surface of the bases is an element whose presence on the film cannot be immediately detected and whose exact composition and characteristics would only be able to be controlled by means of chemical analysis.

In negatives and duplicates, sometimes these treatments can only have been on part of the material and, on a fair number of occasions, without the laboratory informing the owner of this fact.

These treatments can have negative effects on the conservation and their existence must be considered when it comes to establishing the storage conditions of the materials that have undergone it.

In general, materials presenting these treatments must be regarded as higher risk and be conserved under more rigorous conditions than those of similar value and characteristics which have not undergone them.

8.22 - Gelatines

Photographic gelatines are products requiring a highly purified preparation, though one in which very homogeneous results of high purity can be obtained.

The conservation of the optimum levels of humidity is a basic criterion in designing the storage conditions for photographic emulsions.

These levels fall within relatively tight margins: between 25 and 50%RH[193]. Below these margins, the emulsions will release humidity to the atmosphere, endangering their coherence and their adhesion to the base; and above it the continual absorption of humidity will soften the emulsion to the point where it could dissolve.

As stated in earlier sections, excess humidity entails a danger of the proliferation of micro organisms (bacteria and fungi) in the gelatines.

But micro organisms are always present. Unless the film has been sterilised (for example, by using a radioactive isotope) and conserved in sealed containers, then microbiological contamination is inevitable.

But contamination can remain "latent", as spores or isolated bacteria, or it can develop and form millions of colonies and produce serious damage to the image if the conservation is under conditions of high humidity and temperature or if, for example, there are deficiencies in ventilation together with humidities of 50% or higher.

8.23 – Silver image

The silver of the emulsions is a reasonably stable material without any major conservation requirements.

As far as the conservation of the silver image is concerned, a film which has been adequately washed in the final phase of its processing could be conserved indefinitely under the conditions of a standard archive at 18ºC and 50% RH. In practice, the deterioration of the silver image takes place due to the degradation of bases or gelatines or due to the effect of the processing residues.

The silver image is the most stable component of photochemical films and, consequently, for fixing the conservation conditions of films with a black and white image it is the needs of the bases and gelatines that have to be heeded.

In order to eliminate the remains of the fixer used during the processing (usually referred to by the not entirely correct term of "hypo-residue"), the archives can follow two complementary paths.

In reproductions which are directly controlled, it must be guaranteed that the final wash is carried out with sufficient intensity and duration for eliminating the residues.

In reproductions directly controlled by the archive, a second wash with water can be used.

Films that are already processed can also be “rewashed” but only those that do not present any splitting or detachments in the emulsion or erosions (produced by rubbing on rollers and runners) in their edges.

The "rewash" will be highly efficient, even in films that have been processed for some years, for eliminating the remains of sodium or ammonium thiosulphate which can cause fading of the silver image.

193 Some sources, such as the ISO standard mentioned earlier, give 20% as the absolute minimum for relative humidity in stores.

8.24 - Colour

The motion picture industry has used dyes of almost all types (among them some of the most unstable) and it has introduced them into films via many different systems.

Dyes have been used for modifying the characteristics of the image, being spread directly onto the surface of the films in hand colouring systems, in stencilling and tinting and in the Dufaycolor procedure; they have been used for forming the image in copies (Technicolor), for replacing the already processed silver (toning) or, during processing in chromogenic systems, for forming a second image, in colour, proportional to that initially formed in black and white by the silver.

8.241 - Dyes introduced in prints

In general, the dyes used during the silent period in subtractive systems, which introduced the colour by means of toning or in Technicolor, are reasonably stable products. But the procedures used in their manufacture and in their introduction on the prints were not sufficiently consistent. The conservation and restoration of prints coloured by these procedures run up against the impossibility of determining which were the exact tonalities of the colours introduced in each print and the degree to which they have faded or darkened with time.

The existence of these colour elements in films with celluloid base prior to the introduction of talking movies or the popularisation of chromogenic systems must be borne in mind when it comes to planning their conservation. Some dyes, such as Prussian blue, are particularly sensitive to the action of gases produced by the decomposition of the nitrate.

The colouring systems in silent movies was also used in narrow-gauge bases (9.5, 16 and 28mm) for prints of films destined for the family use and in some very late two-colour systems such as Cinefotocolor. Acetate bases seem not to have affected dyes.

8.242 – Three-layer emulsions of chromogenic systems

The most unstable dyes are used in chromogenic systems of the substantive type[194] and conservation of the colour in these films constitutes one of the most serious problems with which the motion picture industry is faced.

These emulsions are very sensitive to the action of the degradation products of the bases, and to the action of high humidities and temperatures, and the processed image can become completely spoiled by any alteration in just one of the three colour layers it comprises.

Even under standard archive conditions, at 18ºC and 50%RH, the fading of the colour can start within a few years. Higher temperatures and humidities provoke rapid deterioration of the cyan or yellow images; the magenta image is less sensitive to heat and to humidity, but it can fade due to the combined action of light radiation and extreme humidities, even at temperatures as low as those permitting the formation of ice.[195]

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[194] Due to the characteristics of the dyes and of the processings, films with non-substantive systems, such as Kodachrome, display greater resistance to fading.

[195] See chapters 2.152.31 and 32 of section one. The difference in the behaviour of the magenta was also detected in accelerated aging experiments conducted by Tulsi Ram (see reference in Note 37); this

The characteristics of the processing play a fundamental role in the conservation of this type of emulsion. The aggressive developers and the high temperatures and speeds characterising the developing of projection prints, as well as residues from processing baths that have not been eliminated due to deficient washing, are the cause of the enormous speed with which the colour of these reproductions can fade.

Right now, there is little or nothing that can be done to remedy the effects of the aggressive processing systems used in running off prints. For obvious economic reasons, the vast majority of archives cannot consider obtaining special prints for preservation by modifying the processing. Also, obtaining identical prints to the release prints using other developing procedures is a task that will require the making of a series of tests which will make this process, which is difficult even in recent films, even more expensive.

Regarding the effects of the residues from the processing, for this type of emulsion it is also possible to carrying out a "rewash" of the film, though in this case if it is not done immediately after the processing and with the same system used as the latter, then it becomes much more complex and risky to perform than in the case of black and white emulsions.

In chromogenic films[196], in the last phase of the processing, use is made of a stabiliser solution for preserving some residues of the baths which will help in the colour conservation and these residues can then be eliminated in the rewash. The inclusion of any stabiliser in the rewash bath may not solve the problem and could even be counterproductive: the stabiliser has to be the same as that originally used or another that is completely compatible. As has been stated, this is a complex problem which the technical experts of the archives have to study case by case.

Since the introduction of polyester bases, the obtaining of separation duplicates, reproducing the image of each colour on a separate film, is a technically safe solution but, as well as being expensive, it is also an incomplete solution: the exact colours which the film makers select for their films are only to be found in the colour prints.

Information on the colour tonalities which each film has is only conserved in the prints, or, even more restrictively, it is only conserved in the prints obtained for the release of the film or in those obtained in the years immediately following the release, in the same laboratory and using the same emulsions and the same grading instructions.

Since the forties of the last century, when chromogenic colour systems started to become popular, emulsions and the processes available for filming and reproduction have changed completely.

Nowadays, using the available emulsions, obtaining the characteristics of the original colour when reproducing a negative – well conserved – from the fifties, will require the genuine work of research and restoration, in which the differences between the emulsions existing for copying in each era will have to be overcome, and so too almost certainly it will be necessary to overcome the

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researcher pointed out that the behaviour of the magenta was worse in ventilation conditions than inside sealed containers.

[196] Use has been made here of data taken from: The Gamma Group: "Film Archives on Line".

lack of trustworthy information on the characteristics originally selected for the colour in each film.

In the current situation, conservation of colour films would have to be made from the original negatives or from a top quality negative or positive duplicate or on separation duplicates and, if from a projection print, preferably one obtained for the release.

Evidently, if the situation of film conservationism were optimum (not only good but optimum), conservation of all the materials necessary for preserving the colour (or, if this is the case, of the materials really available for each film) would have to be considered over an indefinite period.

Standard ISO18911:2000[197] defines the very long-term conservation conditions (extended-term storage conditions) as those which are valid for ensuring the preservation of the materials, without loss of information, for 500 years and, of course, 500 years is a period which can be accepted as being equivalent to indefinite preservation.

According to this ISO standard, at 21ºC and 50%RH the durability of the colour can only be guaranteed for 10 years. In order to achieve a durability of 500 years, the ISO proposes three types of ambient condition: 2ºC and 30RH; -3ºC and 40%RH or, finally, -10ºC and 50%RH.

In spite of the rigour of the conservation conditions stated here, if the ISO recommendations are guilty of anything, it is that of being optimistic. Most of the proposals that have been made in the last twenty years for the conservation of colour recommend situations of freezing and humidity that is around 30% and even lower.

Possibly, trying to predict valid conditions for the conservation of such unstable, diverse and complex materials and colour film for 500 years is an impossible task.

Current chromogenic systems have been in existence for little more than sixty years and they will almost definitely not last another sixty years. And there is no security at all regarding the future of photochemical cinematography nor on the technological alternatives that might survive the in electronic cinematography.

The electronic image, which functions as an additive colour systems, is replacing photochemistry, and, although the latter still has a lot of life left in it, from all the forecasts it is possible to predict right now, by the start of the 22nd century either the manufacture of photochemical films for cinematography will have disappeared entirely or, if it exists, it will be on technical basis that is totally different from those currently in existence as far as colour reproduction is concerned.

But the situation of film conservationism is not optimum (in fact, in most countries it is not even good) and, together with the recommendations for the conservation of colour films in the very long term, it will also be necessary to introduce other considerations for ensuring the possibility of preserving all the

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[197] ISO 18911-2000: "Photography - Processed Safety Films - Storage Practices". International Organisation for Standardisation, Geneva, Switzerland.

information on the colour of each film – and of transmitting this information – until the new image systems have consolidated their standards of quality and bases of the future cinematography.

From these points of view, for cultural archives it might be necessary to accept two types of approaches in relation to colour preservation:

- An approach of minima, aimed at guaranteeing the preservation of the possibility of faithfully reproducing the colour of current films on cinematographic image systems that might be used within, for example, a hundred years.
- A very long term approach, aimed at guaranteeing the indefinite conservation of colour on its colour bases, in order to protect it from the alternatives and the moves of industry and cultural authorities.

8.242.1 - Strategies for the conservation of films with chromogenic emulsions on safety bases

The possibilities that are raised are in many aspects complementary.

8.242.11 - Conservation of prints for use in projection

Conservation prints for frequent use, for example: leaving the archive for periods no greater than a week and which remain acclimatised under conditions no higher than 21ºC and 50-60º of humidity during their stay outside the warehouse.

These intensities of use can imply an average of use of 100 projections – very carefully done – for the entire existence of a print. This type of use would represent the maximum foreseeable durability for a print under the functioning conditions of the archives.

A) Conservation period: 50 years
Ambient conditions: 15ºC +/- 3º annual variation (from 12 to 18º)
40%RH +/- 5% annual variation (from 35 to 45%)

8.242.12 - Conservation of image and colour information on photochemical bases

These materials would only leave the store for serving as originals or as control elements, in making new reproductions or restorations.

Projection prints of very infrequent use or which are in reserve while other prints of the same films are being used can be conserved under these conditions.

B) Minimum conservation period: 100 years
Ambient conditions: 15ºC +/- 2º annual variation (from 13 to 17º)
30%RH +/- 2% annual variation (from 28 to 32%)

C) Maximum conservation period: 200 years
Ambient conditions: 10ºC +/- 2º annual variation (from 8 to 12º)
30%RH +/- 2% annual variation (from 28 to 32%)

In the above three proposals, the conservation can be carried out with ventilated containers in fully conditioned warehouses; or in sealed containers and using adequate amounts of zeolite crystals, if conservation were carried out with the stated temperatures but with greater variations.

D) Conservation period: greater than 200 years

D1) Conservation in ventilated containers
Ambient conditions: 5ºC +/- 2º annual variation (from 3 to 7º)
30%RH +/- 1% annual variation (from 29 to 31%)

D2) Conservation frozen
Sealed containers.
Ambient conditions: - 5ºC +/- 2º annual variation (from -3 to -7º).
25-30% relative humidity.

For films included in these last two proposals, the possibility can also be considered of conserving the image information separately, by means of separation duplications in black and white, and the conservation of the colour qualities by means of prints or even fragments of a print of just one or two frames of each shot.

E) Colour films with acetic degradation
In these emulsions, even in the initial stages of degradation, the acetic acid modifies the characteristics of the yellow-sensitive layer.

In order to conserve these films and be able to use their information on the colour in a future restoration, they can be stored in containers sealed with zeolite absorbents or by freezing under very rigorous conditions (less than 16 degrees below zero and 20-30%RH).

8.25 – Magnetic Coatings
As mentioned in section one[198], a wide variety of plastic resins have been used in magnetic coatings which, in practice, makes any classification for conservation impossible.

In general, all these resins are stable products which (within the standard margins of temperature and humidity of archives) could be conserved very well, if it were not for the interaction between the ferromagnetic particles contained in the coating and the plastics of the bases.
The interaction between metallic oxides and the triacetate is particularly bad in the films carrying magnetic tracks adhered to it (striped films), given that, in order to improve the adhesion during the application of the magnetic paste, the emulsion or the base needs to be abraded .

M. Edge points out that the high porosity (more than 20%) which these resins must have so as to satisfy the mechanical characteristics for use , favours their degradation by oxidation and by the action of humidity[199].

Very low relative humidities (below 30-35%) can harm the coherence and adhesion of the resins.

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[198] See chapter 2.23.
[199] Michelle Edge: "Approaches to the conservation of film and sound materials". In: Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000. Pp. 14 to 34.

High humidities and temperatures favour oxidation of the metallic particles in the emulsions and of the vaporised metal. These conditions also propitiate the proliferation of micro organisms.

Temperatures below 8ºC cause the separation of the lubricant and the resin, so this temperature constitutes the lower limit for the conservation of magnetic tapes.[200]

For the conservation of films with magnetic emulsions, two complementary recommendations can be made:

F) PVC or polyester tapes and perforated polyester films
Temperatures lying between 15 and 18ºC
Relative humidities of 40-45%.

G) Acetate films with magnetic coating or with tracks adhered
The conservation of these films might not possibly be guaranteed.

The safest conditions that can be recommended place the temperatures at between 8 and 10ºC and the relative humidity at between 30 and 40%RH.

8.26 - Bases
The plastic of the base accounts for more than 90% of the mass of each reel, and the loss of its mechanical characteristics will hinder the reproduction of the film or make it impossible, and its chemical degradation will rapidly affect the rest of the components.

The conservation of the bases is the critical element of the entire conservation process of films.

8.261 - Celluloid
Both for reasons of conservation and for those of public safety, it is an essential rule to group together films with plasticised cellulose nitrate bases, separating them from all the others.

From the point of view of conservation, it is sufficiently demonstrated that the gases produced by the chemical decomposition of celluloid bases cause serious damage to the stability of gelatines and dyes and to the rest of the plastic bases.

All nitrate bases must be kept in special stores located in isolated buildings.

Due to the possibility that these materials can spontaneously combust and because it is impossible to extinguish the fire until all the nitrate has burned, the separation of these materials cannot be confined to locating them in warehouses different from the rest of the materials.

Warehouses prepared for films with inflammable base must be located in separate buildings intended solely for this purpose and with work areas (if these exist in the building) that are totally isolated and protected.

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[200] Standard ISO 18923: 2000. "Imaging materials – Polyester-base magnetic tape – Storage practices", International Organisation for Standardisation, Geneva, Switzerland.

Fire-fighting devices will be focused on preventive measures that limit that capacity of these stores (see chapters 9.22 and 9.41) and control the efficacy of the isolation devices.

Although the criterion of hazardousness is what predominates in the classification of films with celluloid base, and although in most cases these films have silver image emulsions, in many prints the image is formed from dyes or dyes have been used for modifying the image. The degradation of the celluloid modifies the dyes and, depending on the composition of collections, the archives must consider the possibility of classifying its colour materials separately (though in the same isolation situation).

Fundamentally because of its danger and because of the loss of characteristics originated by the evaporation of the plasticiser (shrinkage and fragility), most archives base the preservation of films shot on these bases on the reproduction of the original on safety bases. In these regard, J.S. Johnsen, when stating the conservation conditions selected by his archive[201] and citing works from the Image Permanence Institute, says that, properly conserved, many of the celluloid originals will last longer than the duplicates obtained from them on acetate bases.

The conservation criteria for celluloid are based on control of temperatures and stability in the storage.[202]

Plasticised cellulose nitrate is much less sensitive to excess humidity than acetates; nevertheless, very low humidities accelerate the shrinkage and reduce the mechanical strength of the plastic.

There are two basic sets of recommendations that have been produced for the storage of these materials.

H) For ventilated containers

6ºC and 50-60%RH.

This relative humidity, which is undoubtedly adequate for forestalling the deterioration of the physical characteristics of the nitrate, can be very high for prints with added dyes, which were very common in the silent cinema.

I) For freezing and sealed containers

-5ºC and 30%RH.

The conservation of films displaying “active” chemical decomposition in any of the first three phases of development[203] can be very complicated. Convolutions affected by the decomposition tend to become stuck to adjacent convolutions, a tendency that becomes more severe the lower the humidity of the storage.

Given that the films in the first phases of decomposition can still be reproduced (even if fragmentarily), separating the zones affected by the decomposition, locating them in separate containers and keeping them with

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[201] Jesper Stub Johnsen: "From condition assessment survey to a new preservation strategy for The Danish Film Archive". In: [jesperj@dfi.dk, www.dfi.dk]

[202] See chapter 1.411 of section one.

[203] See chapter 1.411 of section one.

very open winding, is a technique (evidently desperate) that can allow one to gain the necessary time until this reproduction has been completed.

8.262 – Safety bases

Throughout its history, the motion picture industry has used five types of non-flammable base, three of them derived from cellulose – diacetate, mixed esters and triacetate – and two synthetic plastics: PVC and polyester.

As was emphasised in the chapter devoted to bases in section one, the level of knowledge on the characteristics and conservation needs of all these plastics is highly irregular.

Although they are currently being replaced by polyester, triacetate is still the most important plastic material for archives and the one on which most films are conserved.

8.262.1 – Diacetates and mixed esters

Diacetate was the first plastic used as safety base in films. On account of its dimensional instability, derived from its low impermeability index, the industry did not come to accept it for professional film making.

As a relatively permeable material, it is especially sensitive to the action of humidity, therefore its degradation is produced via hydrolysis mechanisms similar to those described for triacetate.

It would be much more correct to talk about "diacetates" than diacetate. There exist important differences among the manufacturing systems used by the different manufacturers and, moreover, during the more than thirty years in which this base lasted, a great many modifications had to be made to the manufacturing procedures. All these differences and modifications (which can be totally undetectable for the archives) have to have a reflection in their conservation and degradation characteristics.

Henning Schou, in "Preservation of Moving Images and Sound", recommends the conservation of these bases under conditions similar to those of films with colour emulsions.

The scarce data available on the characteristics and conservation of butyrate and propionate acetates seems to indicate that mixed esters can be conserved under the same conditions as triacetates.[204]

8.262.2 - PVC and polyester

The chemical stability of these bases, particularly that of polyester, seems to be superior to that of other plastics used in the cinema.

As far as the conservation needs of the bases are concerned, it appears that the films and tapes manufactured on PVC or polyester could be adequately conserved under standard conditions of 18 to 21ºC and 40-50%RH.

Video and audiotapes manufactured in these plastics, as well as magnetic perforated films in polyester can be conserved under the conditions stated in chapter 8.25, concerned with magnetic coatings.

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[204] On the few occasions in which these types of plastic have been detected in materials of the Filmoteca Española [Spanish Film Institute], the state of conservation of the base (contraction, buckling, etc.) were entirely similar to that of triacetates of the same era.

For the conservation of those made of polyester with photochemical emulsions, it will be necessary to attend to the needs of those emulsions.

Polyester appears to be sensitive to the action of the acetic acid produced by the degradation of the triacetates, therefore it would perhaps be appropriate to consider storing the two plastics separately.

8.262.3 - Conservation of triacetate bases

Triacetate bases of plasticised cellulose constitute the bulk of current film collections.

Archives do not just conserve the films that were originally made on these bases but also the immense majority of preservation reproductions of films shot on other types of base have also been made on triacetates.

All the criteria for film conservation revolve around the conservation requirementsand needs of this plastic.

Some of the dyes used in the colour emulsions are even more unstable than the triacetate bases and it is therefore their conservation needs which determine the storage conditions for chromogenic colour films. These conditions have been discussed in the different headings of chapter 8.242.

The conservation possibilities of films with magnetic coatings have been considered in chapter 8.25.

8.262.31 - Strategies for the conservation of films with black and white emulsions on safety bases.

The silver image is a more stable element than triacetate; therefore, when considering the conservation of films with black and white emulsions, it is the base which will determine the storage conditions.

In order to homogenise the proposals, the recommendations and classifications made below have followed similar criteria to those used in the discussion of recommendations on conservation of colour.

In the first three proposals (J, K and L), the conservation can be done with ventilated containers in fully conditioned warehouses or in warehouses that are just conditioned in terms of temperature, with sealed containers and zeolites.

J) Conservation of prints for use in projection

As the conservation that is considered for this type of print only aims to provide preservation of the material until the deterioration produced by use compels its replacement, the conditions that are recommended are identical to those stated for colour emulsions.

Conservation period: 50 years
Ambient conditions: 15ºC +/- 3º annual variation (from 12 to 18º)
45%RH +/- 5% annual variation (from 40 to 50%)

Black and white materials with polyester bases, including archive prints and those with very low frequency of use and duplicate negative used for making new prints can be conserved in the same conditions.

K) Materials for reproductions or very low frequency of use
Conservation period: greater than 100 years
Ambient conditions: 15ºC +/- 3º annual variation (from 7 to 18º)
40 - 45%RH

All duplicates, including separations, with polyester bases can be conserved in these same conditions.

L) Exclusive preservation and restoration materials and diacetate bases
These conditions cover the indefinite conservation of the materials.

L1) Conservation period: greater than 250 years
Ambient conditions: 10ºC +/- 2º annual variation (from 8 to 12º)
40%RH +/- 3% annual variation (from 37 to 43%)

All the preservation and reproduction materials that have been subjected to polishing treatments must be conserved under these conditions.

L2) Indefinite conservation
Using ventilated containers:
5ºC +/- 1º annual variation (from 4 to 6º)
30%RH +/- 3%RH annual variation (from 27 to 33%)
In freezing and sealed containers
- 4ºC +/- 1º annual variation (from -3 to -5º)
25-30% of relative humidity

Triacetate bases that have passed the "autocatalytic point" in their degradation process must be conserved in a extremely low temperature (-16ºC) until they can be reproduced.

9 – The storage cycle

If documentary materials are conserved so that they can be used again, then the development of the storage could be described as a cyclic activity, whose stages – preparation for entrance storage and preparation for use – must be coordinated in such a way that the materials, the films, can travel along them time and again.

The actions that are carried out during the storage cycle are classified into four groups.

Those coming in the first three groups are carried out consecutively, following the natural course of the storage cycle: entrance, storage and exit. In the entrance and exit preparations the tasks are focused on each material, in actions which could be described as “individualised". On the other hand, during storage, the actions refer to the materials as a whole and individualised actions on a particular material can only be considered when starting on its path towards exit or when the control or sampling systems established for the materials as a whole state should be carried out.

The control and safety tasks included in the fourth group are developed throughout all the phases of the cycle. In these actions, the conservation of the materials, the functioning of the equipment and systems installed in the archive, and peoples’ safety, are all considered as parts of the same task.

9.1 - Preparation of the materials for conservation

Preparing the materials for storage, from their arrival at the archive for entrance into the store, implies carrying out, reel by reel, film by film, a set of inspection, classification, cleaning, conditioning and packaging tasks which will be those that require the greatest investment effort among all those made in the archives. Simultaneously, this set of tasks are the most important of the actions which must be established in the archives.

9.11 – Technical cataloguing and classification

Although depending on their objectives and possibilities, each archive will have to establish its own criteria, in general terms and when dealing with materials entering the archive for the first time, the identification and classification of the materials has to cover the following aspects:[205]

- Identifying the material, establishing the filmographic and administrative data necessary for relating it to the film it belongs to, as well as those legally justifying its arrival and stay in the archive.
- Determining the technical origin and type of material, plus its characteristics of quality, state, continuity and possible uses and conservation.

[205] Some of the elements used in this part come from: A. del Amo. "Inspección técnica de materiales en el archivo de una filmoteca". Filmoteca Española, Madrid, 1996.

- Relating the material with the rest of the same title possessed by the archive, and establishing its importance for the conservation and reconstruction of the film.

With materials returning to the archive after having been used, the tasks are reduced to those necessary for detecting possible deterioration.

This stage of cataloguing and classification of the material could be done in accordance with the criteria stated in chapter 5 of section one.

The existence of a good technical catalogue of each material will avoid the unnecessary repetition of inspections and checks and will aid decision-taking by all users, from those in charge of programming access materials up to those who are studying the carrying out of reconstructions and restorations.

9.12 – Rewinding for inspection

Rewinding is one of the crucial techniques in the handling of films but, simultaneously, rewinding a reel of film is an apparently simple operation and is frequently done routinely and/or without care, making it easier for film to be damaged.

When a used film arrives at the archives, the people in charge of inspection cannot know what damage might appear behind each of the irregularities observed on the surface of the reel. Splices that are old but sound and well done, and a break, can look the same until the moment in which the affected convolution is reached during rewinding.

The first rewind of an old film showing signs of deterioration or of repairs to the surface of the reel must never be considered as a routine operation, and must be done with a manual rewinder or with a motorised one that can run at very low speeds.

There are two types of manual rewinders.

In the oldest ones, the plates are arranged vertically. Their handling is very delicate and requires skilled and patient personnel, though they can be preferable for the winding of films which have arrived at the archive in a very bad condition or with a lot of dust or remains of rust.

Working with these machines, the operator can monitor the state of the material perfectly and, moreover, a large part of the dust deposited on the film (not that adhered due to humidity or grease) will fall directly onto the work table.

Horizontal plate machines are much more convenient for working with and less hazardous for the material.

As mentioned, the rewinding of nitrate materials showing signs of active decomposition is a problem for which there are no entirely satisfactory solutions.

Direct contact with the affected convolutions is the quickest way of transmitting this degradation and, when rewinding a reel with isolated decomposition stains, the stains will inevitably change position on the reel and their sticky exudation will affect frames that were previously clean.

In order to tackle this problem, when dealing with valuable materials for conservation of the film and which cannot be reproduced immediately, there are three complementary possibilities that can be considered:

- Trying to reduce the stickiness by means of ventilation drying, carrying out a very slow manual rewinding and, if necessary, with the aid of liquids such as perchloroethylene.

The use of these liquids entails a risk for health and must be carried out using gloves and full masks with adequate filters and protection for the eyes. This treatment does not halt the decomposition but it can provide results when it comes to slowing down its propagation, particularly when this has occurred due to storage in very humid atmospheres.

- Cutting the parts showing active stains, conserving them in separate containers and with the winding as open as can be achieved.

- Not rewinding, leaving the reel as it is.

These three alternatives can give results (but also have no effect) if the conservation of the material is carried outin very cold, dry conditions up to the moment when reproduction becomes possible.

9.13 - Control over chemical degradation

If the archive has controls introduced for detecting the chemical state of the bases, doing this during this stage when each material has to be inspected reel by reel will imply a major economy of effort and, moreover, will allow the history of the conservation of each material from the moment of its arrival at the archive to be developed.

In acetate bases, the "A-D Strips", prepared by the Image Permanence Institute[206] for the detection of acidity, permit the possible existence of degradation to be controlled in a simple, quick and reasonable way, and without it being necessary to effect any destructive actions on the material.

In order to carry out these tests, inside each box, on each reel of film, a strip of absorbent paper is placed impregnated with a substance that reacts and changes colour in the presence of acids produced by degradation. The speed of change of colour (which is variable depending on the type of control strip used) will indicate the existence of degradation and, as the case might be, the level of acidity reached by the film.

Archives must consider the possibility of systematically carrying out this control on all those materials which are not completely new on their arrival at the archive, as well as the conducting of periodical controls on a statistical sampling base, in order to determine the state of conservation of already stored materials.

In nitrate materials, the most important aspect of the inspection is simply to detect its existence.

The safety of people, of the rest of the materials and of the archives themselves can depend on the effectiveness of systems introduced for the immediate detection of cellulose bases arriving at the archive. When adequate precautions are taken, working with nitrate films is not a particularly hazardous

[206] See information on the use of these strips in: J.L. Bigourdan and J.M. Reilly (Image Permanence Institute): "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome: Preservation Strategies for Acetate Base Motion-Picture Film Collections". In: Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000. Pp. 14 to 34.

There exist other similar strips prepared by commercial companies.

activity; the risk lies more in the ignorance that one is working with inflammable materials.

The determination of the degree of decomposition that occurs in nitrate has to be done via two different methods.

The first refers to the detection of situations of "active decomposition" which were described in chapter 1.411 of section one.

All reels of film with celluloid bases have to be rewound before entering the warehouses. In their initial states, the effects of the decomposition may not be revealed from the outside of the reel, so rewinding is the only really effective system for detecting these situations.

The decomposition can have developed in a single reel and it can be in the initial states in which it will still be possible to reproduce the film. On the other hand, in the "active" phase of decomposition, films emit a large amount of gases which contribute towards spreading the degradation throughout the entire warehouse.

The second type of control is a test aimed at detection of "latent" degradation and is similar to that described for detecting acidity in the safety bases.

There are various systems[207] and the best known is the "alizarin red test".

The procedure to follow in that test is relatively simple:

A) – A sample of film, of between 6 and 10 millimetres in diameter, is placed in a test tube and hermetically sealed.

B) – Before sealing the tube, a strip of absorbent paper, which has been submerged in a solution of alizarin red and dried, is wound round the stopper. The strip must penetrate into the inside of the tube and extend to the outside.

C) – The test tube is partially introduced into a heater with a xylene steam bath at 134 degrees centigrade, looking for a change in colour of the paper from the original pink to a pale yellow.

The speed of the change in colour will indicate the prospects for conservation of the sample.

- Situation 1. The change in colour takes place within an hour: the material is in danger of decomposition and action must be taken immediately.
- Situation 2. It takes between 60 and 120 minutes: it is worth while repeating the control.
- Situation 3. No change in more than two hours: the material is stable.

In principle, for materials in "situation 3", it would be worth while repeating this test every five years, but this repetition and even the conducting of the test on arrival of materials at the archive, clashes with that stated in point one, where it says that samples have to be taken of film intended to be conserved.

All the original negatives that were produced on nitrate bases, plus the immense majority of prints from the silent era, are made up of many different materials, spliced together. Moreover, on the prints that were made, many different colouring treatments were carried out which (as is amply

[207] See: H. Karnstädt, G. Pollakowski, V. Opela and D. Rozgonyl: "Handling and storage of nitrate films". FIAF Preservation Commission.

demonstrated) introduce differences into the chemical behaviour of the materials.

In these conditions, obtaining samples does not mean obtaining one sample per reel (which would mean harming a frame) but instead one sample for each different material appearing in the reel, with an average of between 8 and 15 samples in total. Only in prints and duplicates from the talking movies which have been reproduced as a single complete reel (and which have not been re-edited) would one sample per reel suffice.

Extracting various samples for each reel of film is not an easy decision to take for archives and, of course, it is not possible to consider a systematic conducting of this type of test on all materials. Nevertheless, its introduction and application on a statistical basis can be an important aid for monitoring storage conditions.

On the other hand, the effectiveness of this test has been put into question in an important study carried out by the Danish Film Institute.

Karin Bonde Johansen and Mikael Braae, in the study done on the conservation conditions in the D.F.I. archives, established that results of the “alizarin red tests” were not really reliable: in the obtained results, the amount of films in situation 1 or 2 did not correlate to what could be deduced with a visual check on the state of the collection. Furthermore, amongst a share of 13 tested films with visible signs of chemical decomposition, only two of the samples with paper prepared with red alizarin experienced a change before 120 minutes.

The Danish archivists indicate that, increasing the level of incubation temperature, they could possibly obtain results quantitatively more significant but, in any case, the obtained results demonstrated the low corralation of the alizarin test and showed that, at present, the archives don’t have a really reliable system to predict the expectations of durability of the celluloid films in the time required.

9.14 - Cleaning

The industry and archives have developed all kinds of cleaning procedures – from manual ones to automatic – for eliminating adhered elements that might interfere with the transmission of light through the film. But all cleaning procedures can deteriorate the material and this risk will be greater the more intense the cleaning intended to be carried out.

Generally, the procedures developed by industry are made to prepare the film for reproduction, not for film conservation.

The aims of conservation cleaning are much more limited: they are not intended to obtain the maximum cleanliness for reproduction but instead to eliminate all remains and materials that could endanger the conservation of the material.

Rust from containers and other mineral remains (dust) that could be in contact with the film, self-adhesive strips used in repairs, and oily remains: there are three characteristic types of dirt that can be found on films.

Rust particles produce physical damage in the material and can become catalysts for its chemical degradation.

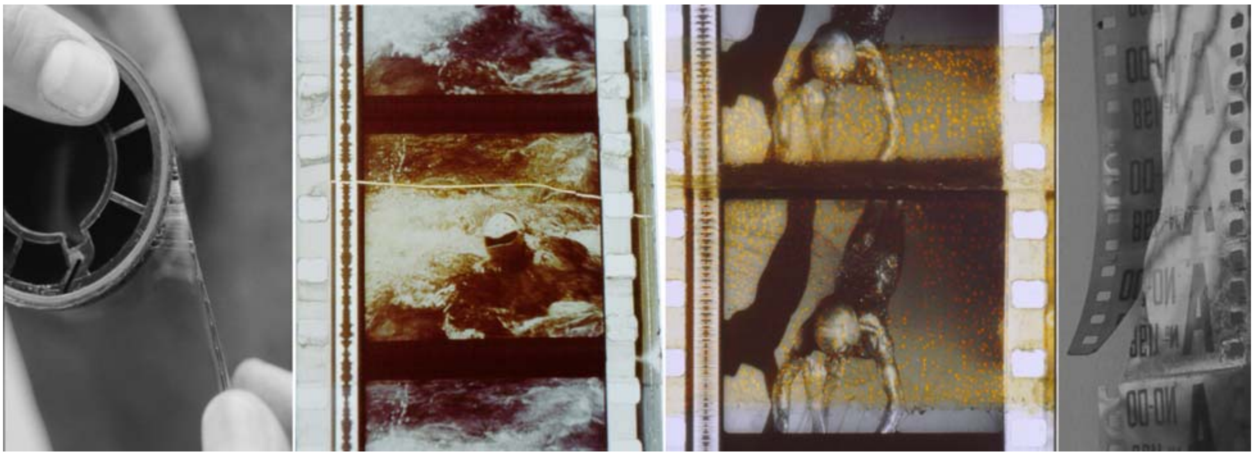
When these particles are not adhered to the film, removing them during the rewinding in a vertical plate machine, with the aid of a clean soft brush, is a simple task.

In containers that are much deteriorated due to humidity, small flakes of rusted iron very often remain adhered to the reel of film; manual damp cleaning is the only possible procedure for its elimination though this is a very laborious undertaking entailing risks for the material and which should normally only be done before reproduction of the material. Within the storage preparation tasks, this procedure may only be considered when the rust is endangering the conservation of valuable materials for the preservation of the film.

All self-adhesive tapes, including polyester tapes specifically labelled for motion picture use, end up by deteriorating the material.

These tapes were introduced into the motion picture industry for the preparation of editing rushes and they have been used for many other purposes, from carrying out splicing in prints up to strengthening of weak points in tasks such as washing or repair of perforations.

Self-adhesive tapes for motion picture use are more resistant and have a lighter layer of adhesive than those for general use, but they will start to lose their effectiveness as an adhesive two or three years after being stuck in place, yet, nevertheless, they will continue to damage the film indefinitely.

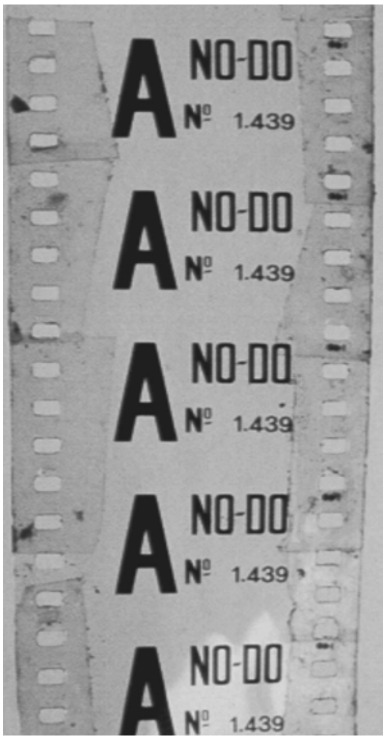


F. 175
(Samples obtained by Jennifer Gallego Christensen)

Self-adhesive tapes produce three types of damage on films:

- Components of the glue cause chemical damage to the film (oxidation and sulphuration).
- When the glue degrades and “exudes” outside the limits of the tape, becoming stuck to consecutive convolutions, spreading the chemical damage and introducing new damage when the film is unwound.
- In its last phase of aging, the adhesive crystallises on the film, causing irreversible damage to the emulsions.[208]

[208] See: Jennifer Gallego Christensen: “Degradación de las cintas autoadhesivas utilizadas en películas cinematográficas”. In: Journal of Film Preservation, n°58-59, FIAF, Brussels, 1999.



In conservation materials, including projection prints which can remain for many years without leaving the archive, self-adhesive tapes should be considered as a destructive element and removed before storage, carefully cleaning away the remains of glue.

In materials destined for preservation or reproduction of the film, in which loss of frames cannot be accepted since this would imply making a permanent splice, it will be preferable to leave the fragments unspliced, clearly stating this situation in the cleaning report and on the outside of the container, and leaving it for the people in charge of preparing the film for reproduction to be the ones who carry out the repairs with the procedures that they consider adequate at that moment.

Of course, all self-adhesive tapes used in reproduction repairs for making splices or strengthening perforations will have to be removed before the material returns to the store.

In theory, grease stains existing on films are not necessarily harmful for the conservation of material; nevertheless, greasy remains will keep mineral particles (dust) stuck to the film if they come into contact with it. Manual cleaning with solvents and chemical cleaning in ultrasonic agitation machines are efficient methods for treating these materials.

Humidity and condensation can also stain and cause particles of dust to become stuck to the film. Washing with water (rewashing) will be able to reduce this type of damage though it will not entirely eliminate it from the emulsion.

All these cleaning treatments are slow, expensive and, except for manual cleaning, when working on old films deteriorated by use, they always entail some level of risk.

The carrying out of a rewash prior to storage of the material would be completely justified if the presence was detected of processing by-products in a sufficient concentration to cause damage to the quality of the image.

9.15 – Winding for conservation

In very prolonged storage, the characteristics of the winding of the film can be important for its conservation.

Uniformity is the most important characteristic in any type of winding. The existence of differences in pressure or of positioning between the convolutions constitutes a genuine invitation for the production of damage to the film.

In that need for uniformity is to be found the origin of the recommendation for all video tapes to be rewound after use and before being stored again. This rewinding must include the entire tape (from beginning to end) and be done in one go, otherwise the tape could display irregularities in which damage will more than likely be caused.

With the rewinding, the conditioning starts for entrance into the warehouse. With it, the film must be left prepared for carrying out the change of humidity and temperature conditions in the most homogeneous way possible.

The rewinding must be done in one go and at a constant speed. Motorised rewinders are available permitting the tension of the winding to be regulated but, for a skilful operator, it is perfectly possible to achieve this result in a manual horizontal plate rewinder.

The differences in tension during the winding will produce differences of pressure and separation between successive convolutions. In these separations will accumulate the steam condensations which will have to pass through the reel.

Changes of speed in the winding or of position in the film will produce irregularities in the positioning of the convolutions, making it very likely that these convolutions will become damaged during transport.

As was already stated when talking about ventilation conditions (see chapter 7.432), unless the conservation is being done in conditions of relative humidity very much lower than the outside atmosphere, the shrinkage of the base will increase the pressure between convolutions, to the point of being able to cause serious damage to the image or to the bases themselves. A smooth winding, done under low pressure and at constant tension, can alleviate this problem.

F. 178
Films rolled for transport and storage. (Photo: Diego Martín)

When the storage humidity is very much lower than that of the atmosphere from which the film has come, the loss of humidity will reduce the thickness of the emulsions; in these cases, in order to mitigate the negative consequences of transverse curving of the film on the emulsion face, it will be a very good idea to carry out the winding leaving the emulsion side facing out.

Winding at low pressure also solves all the problems that can derive from the contraction of a film which has been in storage for many years without any movement at all.

A wound film that is shrinking will "attempt" to solve the problem created by the loss of length by increasing the pressure and sliding its length towards the centre in order to reduce the diameter of the reel; as these two processes cannot occur simultaneously, the sliding of the film will occur, producing damage and even breaks.

Whatever the conservation conditions, periodical rewinding of each reel, leaving the end that was previously next to the core on the outside, will be the most effective way of reducing pressure and ventilating the material.

9.16 – Packaging and labelling

Acclimatisation, packaging and labelling constitute the end of the preparation process.

The criteria on acclimatisation for storage has already been discussed in chapters 7.433 and 7.5; and the desirable characteristics for the boxes were pointed out in chapters 7.431 and 7.432.

For different reasons, in many archives it might be necessary to continue using the original metallic cans.

The degrading actions of metals is not a serious problem in frozen warehouses but it can become so under other storage conditions and, in these circumstances, guaranteeing the ventilation of the interior of the boxes becomes a fundamental necessity.

If it is not possible to use ventilated containers made with non-reactive plastics, then making holes of diameter 3 or 4mm along the lower edge of the boxes would be a task that does not require an major investment and one that constitutes a great contribution to conservation.

Two criteria exist for the labelling of the films, in both of which correlative numbering is used which functions as a topographic signature of the position of the boxes in the warehouse.

The first of these criteria is based on assigning a correlative number to each box; this is a very simple procedure that will be highly effective for positioning each reel in the warehouse.

In the second system, the correlative numbering is assigned to the film and will appear on all boxes making up the material, together with an order number indicating that of each box within the set.

The original negatives and other types of materials are not usually formed of a single series of materials. There are the Image Original Negative and the Sound Original Negative, but there are also sound negatives dubbed in other languages and image negatives edited in "A" and "B", etc...

Although in theory the labelling criteria stated in the previous paragraphs can also be applied to these cases, with a different number being granted to each box, or the same number to all the materials of the same title, problems can appear when it comes to indicating the total quantity of boxes making up each of the materials and the order of each box within the set.

To solve these problems, it is possible to use a third series of numbers, stating the quantity of series making up a material.

As well as the numerical identification, it is also advisable to introduce the title of the material so that it can be read by the storekeeper.
Nowadays, labels are widely used, in which the numbering of the material is repeated written in a bar code. These labels can be read by computing equipment and they facilitate control over entrance and exit to the warehouses.

9.2 - Storage
The criteria applicable to the climatic conditions of storage have already been fully commented upon in earlier chapters, and we are now going to discuss the functionality and safety in warehouses.

9.21 - Films on shelves
Since the standardisation of the talking cinema, the use of three sizes of containers for films, both 35 and 16mm, has become widespread:

- Containers of about 18cm in diameter, usable for 120m reels of film;
- Containers of 26 to 30cm for reels of between 300 and 400m of film, and finally,
- Containers of 34 to 39cm for reels of 600 or more metres.

The existence of reels and containers of different sizes, even within a single film, raises problems of conservation and storage.

Films edited on reels of 600 metres occupy 25% less volume than those shot on reels of 300 metres. Reels of 600m save space and increase the thermal inertia of the warehouses but also, and possibly in the same proportion, they increase the destructive effects of the pressure caused by the accumulation of longitudinal shrinkage in the reel of film.

The increase in the length of the reels has not been on account of conservation reasons - in these cases the archives have no influence. Due to the changes in projection and reproduction equipment and on account of the supply of raw stock by the manufacturers, lengths have been continually increasing and, nowadays, it is possible to load all the film on a single reel in the equipment and load reels of up to 1800 metres in length in the printers, to obtain numerous prints of the same negative reel, going forwards or backwards, without stopping the machine.
Only in restorations archives can consider the reel length in which the originals will be conserved.

In the reproduction of negatives and duplicates, the 20 – 21 frames of advance between image and sound mean that the original cut lenght of the materials should be retained.

However, in prints intended for projection, joining them in reels of 600 metres obtained from negatives edited in 300 meter reels is a reasonable practice, given that it is the ends of the reels which suffer the greatest amount of handling during the preparation of each projection, and that the diameter, approximately 40cm, of the containers for 600 metre reels is a suitable dimension for the transport.

Most containers are round and only accept one reel of film, but square boxes and boxes suitable for accepting several reels also exist.

Introducing various reels in a single container is not appropriate for conservation; two reels in contact can cause mutual damage to each other during transport, and, moreover, maintaining the climatic isotropy inside the containers becomes much more difficult[209].

This practice is only harmless in the case of frequently used projection prints conserved ,wound on spools.

As stated in chapter 7.33, the shelves and the actual boxes of film themselves can constitute obstacles making it difficult to achieve isotropy in storage conditions.

Regularising the distribution of the boxes of film on the shelves and distributing the shelves in line with the position of air inlets existing in the warehouse, can reduce that effect.

When distributing the films on the shelves, it is necessary to consider the size and shape of the cans, the division of masses in the warehouse and the circulation of the conditioning airflow.

In general, square boxes (even with rounded corners) will obstruct the circulation of ventilation currents more than round ones.

As far as the distribution of masses is concerned, the optimum situation would be for all the shelves to hold the same amount of film. Although in theory this situation contradicts the existence of films and reels of different sizes, by adopting certain compromises, it is possible to achieve an efficient distribution of films.

Boxes of film are positioned horizontally on the shelves, in columns of between 7 and 10 boxes in height[210].

In order to regularise the distribution of masses in the warehouse, it is necessary to fill each shelf placing films throughout the entire height provided; the practice of placing one film per column can be very suitable in warehouses of distributors of feature films but it is not so for preservation.

Suitable shelving for the storage of films usually have shelves of length between 80 and 100cm and depth between 30 and 40cm. Shelves of length 80 and 90cm are the ones that can be exploited best. In 80/40 two boxes of 600m or eight of 120m can be placed; in those of 90/30 three containers of 400m or five of 120m.

If the same type of shelving has to be installed in the entire warehouse, then shelves of 90/40 would permit the location of two boxes of 600m, three of 400m or 10 of 120 metres. As can be seen, these proportions imply the distribution of an identical quantity of film in each shelf.

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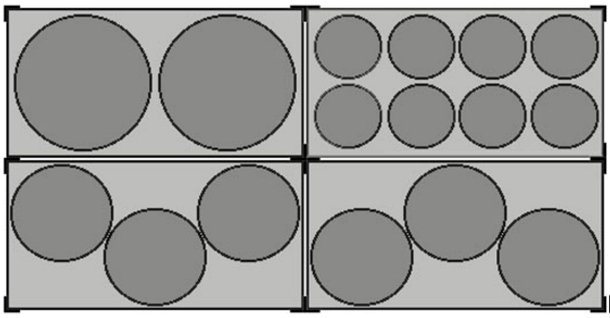
[209] Except if the conservation is done under conditions of freezing and in vacuum sealed bags.

[210] The practice of positioning rolls of film vertically started in the first archives organised by the industry, the ones for motion picture newsreels, which of course were not conservation archives and in which this practice was imposed in order to facilitate immediate access to each roll for being reused. This system leads to the pressure borne by the convolutions in the lower part of the roll being totally different from that on the spirals in the upper side.
Unless all the containers are identical, no more than 10 boxes of 35mm must ever be stacked per column; in higher columns, the boxes in the lower levels could become deformed and cause the weight to rest on the film itself.



F. 179
90x40 cm shelves, with cans for 600, 400 and 120 meters of film.

In preservation warehouses, distributing short and feature films, those shot on single or double reels, and 35 and 16mm material, on separate shelves can help to increase the distribution of masses.

Although planning this distribution will complicate the administrative organisation of the warehouse, by permitting a certain degree of homogenisation of the size of the films and in the dimensions and height of the shelves it will facilitate the distribution of masses in the warehouses.

The distribution of video tapes on the shelves should be according to totally different parameters.

Except in some two inch tapes, all video tapes are located in square boxes provided with a central half-spindle or in rectangular cassettes. These boxes can have different sizes even for tapes of the same format and, moreover, for almost all formats there exist tapes of very different lengths.

The tapes that are located in boxes with a central half-spindle or in cassettes must be stored in the vertical position. The vertical location avoids the possibility of a badly wound convolution becoming crushed by the weight of the tape and, in these types of container, the pressure borne by the convolutions above and below the spindle is very similar.

Organising the distribution of rectangular containers and of such different sizes and masses, in an attempt to respect the distribution of masses and the circulation of the ventilation flow, can be an impossible mission.

The use of shelves of width 22 to 25cm and height 35 to 40cm would permit the space in the warehouses to be exploited to the utmost. In these shelves, large tapes could be laid on their shorter side, while small tapes could be located at various levels, resting on their longer side and using rigid plastic laminas as separators between each level.

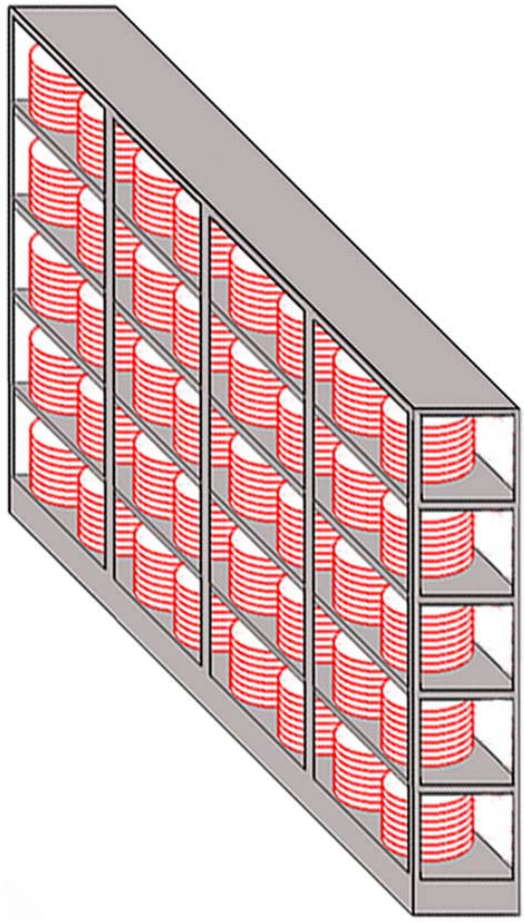
In order to ensure a minimum degree of ventilation, the upper part of each shelf would have to be kept free.

The height of the shelves must also be studyed during the design of the storage conditions.

As stated earlier, the storage conditions can vary with the height at which each film is placed; the higher the shelves the greater these differences can be.

In artificial acclimatisation, it is possible to distribute the air input and extraction devices in such a way that ensures a certain degree of homogeneity in the temperature distribution throughout the entire height of the warehouse, but this is a complex problem and one that can only be solved by means of introducing the hypothesis of flow that includes the filling and emptying of the store.

In general, it is possible to consider that temperature increases deriving from the storage height are staggered in sections of three metres. So, in a shelf of less than three metres in height, the temperature differences ought to be less than 1ºC.



F. 180 Diagram of a 210cm high shelf.

Whatever the type of acclimatisation existing, a free space of height about 150cm must be left between the upper part of the shelves and the ceiling of the store.

This void is essential for the circulation of the warmest air in situations of natural acclimatisation and is necessary so that the dimensions of the input and extraction ducts do not hinder its distribution and the circulation of flows of warm air towards the extraction ducts.

In relation to the heights of shelves, there also is a functional problem which, though evidently minor, is not negligible.

Placing all the films within easy reach is the only really efficient way to prevent operators and technicians, who are locating and withdrawing films from the warehouses, from using the very same shelves as steps to reach a reel of film beyond the reach of a person of normal height.

Naturally, the health and safety regulations of the archives must prevent this bad practice but, we human beings being as we are, and particularly in warehouses with compactable shelves in which it is not possible to have sliding stairs for each corridor, people working in the warehouses will now and then climb up the shelves, damaging them and making them dirty, in order to avoid having to go off in search of a ladder.

9.22 – Capacity of the stores

The response to this question follows different reasoning depending on whether one is dealing with inflammable or safety materials.

For inflammable materials, the limit of the capacity of warehouses stands at between 800 and 1000 reels of 300 metres, in other words, about 2000 kilograms of film. These quantities are advised due to the need to restrict damage in the event of fire and are imposed by the limits of resistance of the materials to fire.

Though there are many differences from country to country, safety regulations require that structural elements and insulating walls and doors must have an adequate thickness and thermal characteristics for resisting and maintaining insulation efficiently for a minimum of two hours and, simultaneously, two hours is the amount of time needed for 2000kg of nitrocellulose to have started the cooling process once it has completely burnt.

For warehouses of safety materials, in theory there are no capacity limits, though in reality, from the viewpoint of stability, the larger and more compacted a warehouse is, the more stable it will be. Actually, and bearing in mind the dimensions of the collections and their growth expectations, capacity limits can be proposed for warehouses.

If the archives were to have their collections in warehouses suitable for quantities of between 25,000 and 100,000 reels of film (when these amounts represent between a tenth and a twentieth of their collections), then major economic gains and gains in functionality could be obtained.

The most important effect occurs on the control possibilities of the storage conditions. These conditions can vary at each point of the warehouse, depending on how full or empty it is and the distribution of the masses inside it. Dividing the archive into a series of relatively small warehouses will facilitate that control and permit stores whose use is not yet needed to be kept empty (and with the acclimatisation equipment switched off).

Moreover, the multiplication of warehouses would permit their classification according to the ambient conditions really obtained in each of them, and their specialisation for films of a certain size (for example, short films), with the shelves being organised in such a way that would permit the maximum exploitation of space.

9.23 - Cleaning

Keeping the warehouses clean and free (as far as possible) of dust and micro organisms is essential and the architectural design of the warehouse should be for achieving this objective.

Warehouses with a regular shape – rectangular or square – and without corners will be much easier to clean.

In the warehouses, there must only be films and shelves; therefore, there must not be any corners or corridors able to become “temporary depots”, suitable for the accumulation of containers or cardboard boxes or any other kind of auxiliary material; not even for cleaning equipment.

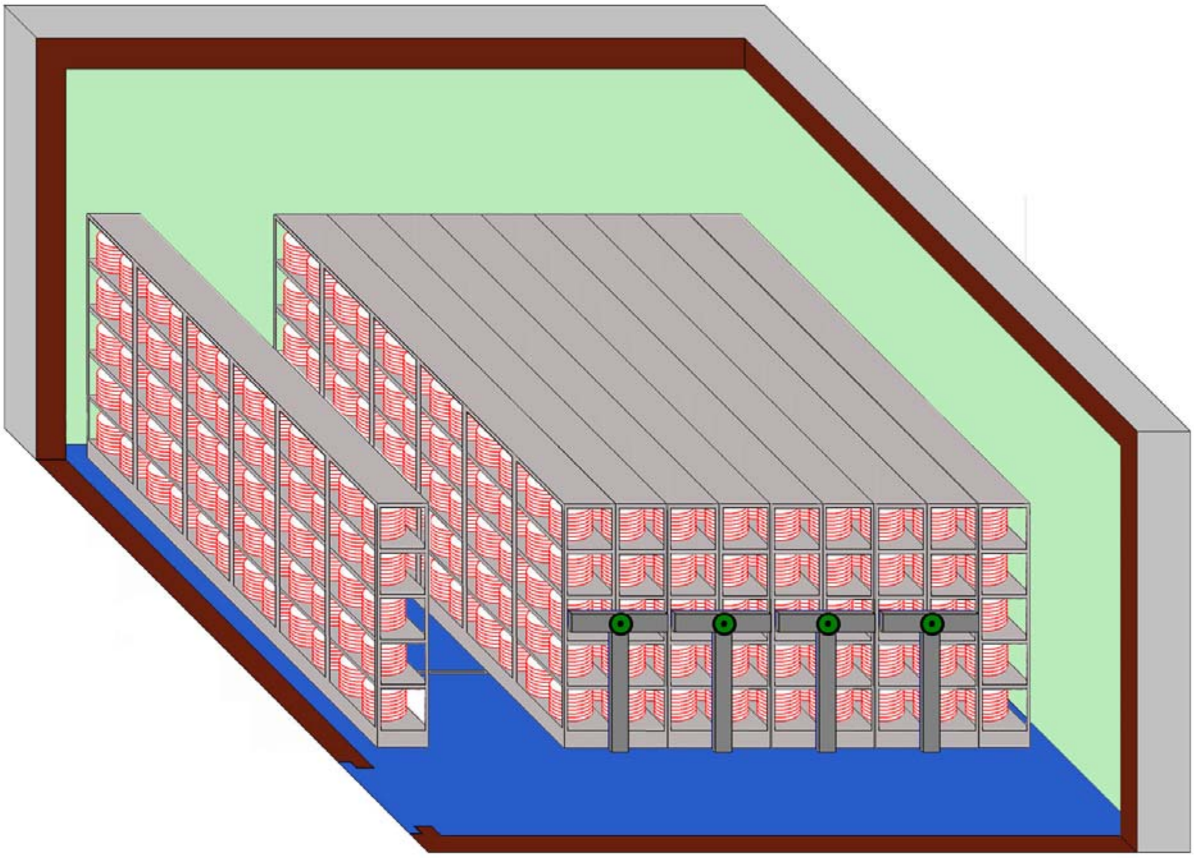
Achieving these objectives is much easier in warehouses provided with compactable shelves.

The use of vacuum cleaners is the only acceptable way to remove dust from warehouses.

The walls and floors must consist of stony or ceramic material, or they must be faced with plastic sheeting or epoxy paints. None of these materials have a tendency to accumulate dust and they do not favour the growth of microorganisms. Moreover, they can be cleaned with aqueous solutions..

A separation between the shelves and the walls of the warehouse, for example of 25 cm, will help to facilitate a complete cleaning of the walls and floors and, at the same time, it will also mean a contribution to climatic isotropy of the warehouse.

Dust and microorganisms have three routes for entering the warehouses: the doors, the ventilation ducts and people entering and leaving.



F. 181
Diagram of warehouse with mobile compactable shelves separated from the wall.

In order to keep stores stable when their construction includes artificial acclimatisation, they need to be designed under positive pressure (higher than in the exterior areas), which will prevent dirt floating in the air from entering via the doors.

Nevertheless, in these warehouses, the air input ducts constitute a magnificent entrance door for dirt, which will only be able to be controlled by installing filter systems and looking after their maintenance and cleaning with absolute regularity. These filter systems must perform three functions:

- Remove the dust and floating mineral remains.

These remains are gathered by means of sieves, which retain large size solid particles, and by means of “gravity traps” (vertical siphons in which particles are driven towards the bottom while the air flow is kept in the intermediate levels). Both systems are very economical and, when combined, they achieve an effectiveness that is almost absolute.

- Absorption of gases and industrial fumes.

Using systems in which metallic sieves and cellulose filters or chemical absorbents of different permeability are combined, it is possible to control most of the oily fumes of industrial contamination.

The effectiveness of these systems is dependent on the analysis of the predominant contamination in the area where the archive is located and on achieving the right composition of filtering panels. Maintenance of these systems requires specialised personnel and a constant renovation of the most delicate components.

- Control of micro organisms.

This problem is without any doubt the one that constitutes the weak point of all cooling systems.

There are many kinds of bacteria (among which are to be found some very dangerous, even deadly, strains for human beings) which, in order to flourish, need conditions of high humidity and temperature existing in acclimatisation equipment.

In theory, the ventilation conditions existing in the air ducts mean that the microorganisms have little possibility of reaching the warehouses. But, besides contaminating the outside, they can survive in a latent state in corners and blind spots of ducts, waiting for a failure in the acclimatisation.

There are filters that can be inserted into the ducts and which are capable of retaining a lot of these microorganisms, but the only really efficient system is to instigate regular procedures for bacteriological analysis and purification and cleaning of the acclimatisation systems. These procedures are expensive and require specialised personnel.

The construction of air locks at the entrances is essential in all types of warehouse. These air locks are simple passage chambers with two doors, one of which must be closed when the other is open.

In warehouses with artificial acclimatisation, air locks are fundamental for preventing leakage of the conditioned air.

It is possible to improve air locks by locating a grille with vertical metallic slats on the floor, capable of retaining the dust falling from the actual boxes of film, from fork-lift trucks or from the shoes or clothes of the operators.

In warehouses with natural acclimatisation, these air locks are the only means possible for preventing or reducing the entrance of dust and outside contamination, and their design takes on considerable importance.

The entrance of people and films and of the acclimatisation air cannot take place via the same route. The ducts provided for the entrance and exit of conditioning air must be fitted with filters and “gravity traps” capable of removing and cutting off the route for dust and other large size materials such as plant pollen.

9.24 – Control of the conservation conditions

A large warehouse is a complex system and if an complete comparision is carried out over the conditions existing at all the points of two identical warehouses, one would find a great many differences the origin of which would difficult to determine.

Only in small warehouses, constructed with totally standardised materials and equipment (like the isothermal chambers of refrigerated lorries), is it possible to repeat the same results time and time again.

As already mentioned, the conditions in the warehouses are defined via the parameters of temperature, relative humidity and cleanness of the air.

In order to establish the system of control over the real conditions existing at each point of the warehouse, it is necessary to have at least three independent thermo-hygrometers.

The first thermo-hygrometer (permanent station or master equipment) would be installed at a fixed point of the warehouse and would be the only control equipment working continuously in each warehouse. The measurements provided by this equipment would constitute the "logbook" of the warehouse and serve as a reference standard for the measurements obtained by the auxiliary thermo-hygrometers.

The auxiliary equipment is moved from one point of the warehouse to another; the measurements are made by placing the two thermo-hygrometers in the same place, one on the lower shelf and the other on the upper one. The points at which the measurements must be made can be determined by studying the topology of the store and of its air flows, also bearing in mind situations of emptying and filling and of the distribution of masses.

Even if high-sensitivity equipment is available, capable of providing almost instantaneous measurements at each point, the measurement must still be done keeping the apparatus at each point for a certain length of time: the cyclic variations in the air circulation can lead to false results when measurements are made over periods of time less than one renewal cycle. In warehouses with natural acclimatisation, this cycle is 24 hours.

Measurements throughout the entire warehouse must be repeated periodically, bearing in mind the annual cycle of temperatures and humidities recorded in the zone and, moreover, whenever any major variations occur in the distribution of films in the warehouse that could modify the ventilation and cooling flows.

After having carried out the series of controls throughout the entire warehouse several times and having checked the results obtained in each control with those provided under stable conditions during the same period of time, it will be possible to produce an isoclimatic map of the warehouse.

This map will permit the acclimatisation systems to be regulated and it can become a valuable aid for the interpretation of the results of the degradation test.

Once an isoclimatic map is available, properly checked and according to the variations of the outside, the data provided under stable conditions can be accepted as representative of the real situation of the store.

9.25 – Statistical control over degradation

As mentioned in earlier chapters, the conducting of the existing tests for the early detection of the decomposition of the celluloid requires a certain degree of destruction of the material and, moreover, it is a fairly laborious undertaking.

Even the carrying out of a test as simple as control over acetic degradation by means of strips like those prepared by the Image Permanence Institute demands a quantity of work that makes it difficult to consider them as systematic controls for all materials.

It is here where the existence of a good isoclimatic map for the store takes on importance.

Obtaining samples or carrying out controls over all the films that are stored can be an impossible and even undesirable task and, as the materials are subject to a dual variable (derived from the differences in composition of the materials and from the differences between different areas of the store), carrying out these samplings on a statistical basis can offer unreliable results.

An isoclimatic map would permit a statistical analysis to be organised, controlling just the materials located at the extreme and middle points of the stability curve of the store.

9.3 – Exit procedure

The period that has to pass between requesting the material and its delivery to the user, as well as the period planned for the return of the material to the archive, constitute the two central elements of the administrative protocol for the exit of materials.

The requirement for rigorously demanding compliance with these periods is the duty of the person in charge of the archive.

The period established for the removal of materials varies first of all bearing in mind the conditions in which the material is conserved and the speed of working of the available systems carrying out the acclimatisation.

The capacity of the reclimatisation system is the second variable. It will always be possible to give exit priority to those materials needing it with greater urgency, though not at the cost of inadequately accelerating the acclimatisation. So, the capacity of the acclimatisation installation can become a limit for the mobility of the archive and, consequently, correctly dimensioning these installations will become a basic need. Each archive must dimension its installations according to the conditions it has established in its warehouses, the size of its collections and the foreseeable demand for use.

The third variable derives from the circumstances of the uses for which the materials are requested; the exit preparation can be more lengthy for materials that are going to leave the archive or to be used in projection than for those that are going to be used in the same installations of the archive or which leave the store for study of restorations or for making reproductions.

As stated in chapter 7.5, materials conserved in drier conditions than those of their surroundings will continue to absorb humidity for some time after their acclimatisation and, objectively, during this period of rebalancing of humidities, both the emulsion and the base will have their resistance characteristics altered.

Although no studies are available on the speed with which materials completely rebalance their humidity, on the basis of experiences mentioned by archives for conditioning prior to freezing, it is possible to estimate that a material which has been conserved under conditions of 30%RH will take between 30 and 60 days to reach a situation of equilibrium with the humidity contained in an ambience of 50%RH.

If the materials do not have to leave the archive (for example, because they have been requested for duplication or for the study of a restoration in the same archive), then having work rooms balanced at 40 – 45% humidity would solve this problem entirely; but, when the materials are to be transferred to other installations, the archives must be studied and a decision reached, case by case, on how the re-balancing process is going to be guaranteed and how they will be transported.

Because of the above, the paperwork requesting the removal of materials must, along with the data on the title of the film, type and quantity of materials requested and the person responsible for the request, also note the reasons for the removal, the place where the material will be used and the expected period for its return to the archive.

Movement control from the warehouse is based on the existence of an efficient system of labelling and, the more rigorous the conditions under which the storage is done and the larger the archive, the more direct and demanding must be the controls over each material leaving the warehouse.

Preventing material from leaving the store by mistake is as important an objective as is making sure that all the reels which have to be used leave. Both mistakes can give rise to unnecessary handling or (and this can be worse) to hasty actions which do nothing but cause damage to the material.

Both the staff in charge of removing film from the warehouses and the technicians responsible for acclimatisation must check the correspondence between the data appearing in the removal request and that written on the labels for the materials.

In this regard, automatic reading labels, of the bar code type, which permit a direct comparison with the data appearing in the computing system of the archive, can be an important additional aid for error detection.

For films that have been in storage for years under conditions of low humidity it can be necessary to carry out a rewind before they leave the archive.

Due to loss of humidity or due to having been loosely rewound films can have inadequate winding conditions for transport. The rewind must not be done before the films have recovered most of their intrinsic humidity.

As stated earlier, plastic bags are not recommended when the storage is carried out in ventilated boxes; on the other hand, packing films in plastic bags is a necessary measure for transport and also to protect them from dust and from contact with the hands of the persons who will handle them, and it would be advisable to introduce the films into plastic bags, for all their stay outside of the warehouse, even when the films do not have to leave the archive installations.

9.4 – Health and safety at work

Looking after the safety of people working in or visiting the archives is a requirement that takes priority over any conservation requirement.

In this respect, the regulations on health and safety at work in force in each country contain the basic rules, which the archive must heed in drawing up its rules ofoperation.

A film archive is not an organisation that implies special levels of risk for its workers and users, it is just that the existence of inflammable bases and the use of chemicals for cleaning films require the existence of special procedures for risk prevention.

9.41 – Working with plasticised cellulose nitrate materials
As stated earlier, safety when working with plasticised cellulose nitrate materials is based on the establishment of the necessary procedures for immediately detecting the presence of this type of base.

The archives must establish an absolutely reliable control system for detecting celluloid, and this control must be carried out immediately on arrival of the materials at the archive, with absolute priority over any other procedure.

The possibility of this priority control is based on a knowledge of the history of motion pictures, both of one's own country and of others from which each film might come from.

Chapter 2.511 states a series of data based both on the production date of the film and on the type and category of the material and the customs of the distribution companies and the release of films at that time which, adjusted for each country[211], makes it possible to establish time limits beyond which all materials arriving at an archive (except when the archive has directly controlled its reproduction or possesses absolutely reliable information on it) must be subject to nitrate detection systems.

Chapter 2.512 states various procedures for verifying the existence of nitrates.

All containers with celluloid films must display a label that identifies the material.

F. 182
Label N°4.1. identificative of flammable solid materials.

211 So, for example, in Spain it has been definitely established that as far as main materials are concerned (negatives, duplicates and prints) the transition from nitrate to acetate took place between 1952 and 1954; nevertheless, on synchronised sound tracks, on originals of image effects and on repetitive materials (such as flash titles and section titles) some nitrate elements have been found in films produced several years after and, during the entire course of the fifties, some distributors continued to "reconstruct" acetate copies that had become deteriorated from use with fragments of nitrate copies.

All the nitrate bases must be in special cells / warehouses located in isolated buildings. Extinction systems are useless. Fire and smoke detection systems must be completely efficient for triggering the alarms and cutting of the air conditioning circuits.

In each cell, at the entrances of the air conditioning ducts, both for input and for return, there must be doors connected to the detection system, that are capable of closing automatically, cutting off the connection between each warehouse and the system when an emergency is detected, and constructed with materials capable of resisting a fire for two hours.

Inside the cells / warehouses the lighting devices, both the cables and the lamps themselves, must be located behind safety ducts and screens, and there should not be any kind of motor or active electrical device capable of producing spark discharge due to the alternation of electrical fields, nor even a socket.

Each warehouse needs to be provided with a duct that permits the flames to exit to the outside. These ducts must be direct and be plugged with a thick layer of isolating material (for example, rigid polystyrene foam) capable of guaranteeing the sealing and the thermal stability of the warehouse, but which literally disappears with the action of the flames.

Except when done under freezing conditions, ventilation is fundamental in celluloid warehouses. The gases produced by decomposition can be toxic and, if they accumulate in enclosed premises, could reach the point of being explosive.

Naturally, in buildings where the rest of the offices of the archive are located, permanent stores for these bases cannot exist.

The archive should have a “day store” for custody of films on which research work or inspection, reproduction or restoration tasks are being carried out, which would contain just the reels of film directly involved in the work in progress.

The capacity of these stores should in no case exceed the needs of the daily works in the archives. The materials should be taken from the day store directly to each workroom and be returned to it when it is finished with.

This type of day store would have to be located in isolated and fully controlled zones (for example, the roof of the building) and have separate cooling systems, which must be connected to an emergency electrical generator unit, along with protection devices against direct solar radiation.

As already stated above, working with celluloid materials does not have to be especially risky, in fact, until the fifties of the last century, the motion picture industry made massive use of these bases and, in spite of the dreadful working conditions existing in many laboratories, the number of accidents was not particularly significant.

Nowadays, in archives, the volume of work done with inflammable bases will never reach a small fraction of the volume that was done in a very small laboratory in the thirties or forties, and in those laboratories all 35mm film was celluloid.

By adopting relatively simple precautions and, above all, preventing routine practices, the archives can continue to work with these films without any risk for their personnel.

International standards for the transport of hazardous goods defines films with nitrocellulose base as “inflammable solid material” (non-explosive), classified with UN No. 1324, in group 4.1,3c.

For the transport of these goods via, land, air or sea, a “Transport Declaration” needs to be made, for which there exist standardised printed forms in each country.

Boxes of film must travel within a solid container made of cardboard or metal sheet, on which appears the hazard label type 4.1. shown in the figure 182.

The Preservation Commission of the FIAF has published different recommendations, based on the experience of archives, on precautions in the handling and conservation of celluloid bases. These publications have been quoted during the course of this work and appear the in bibliographic appendix.

9.42 – Working with products for chemical cleaning

Chemical cleaning is a habitual practice in the motion picture industry and, although none of the liquids used gives off poisonous gases, they can all be toxic if breathed in over a certain period of time.

The concentration of the gases produced by these liquids in the atmosphere of the work rooms must remain below 300 parts per million. Legislation on health and safety at work does not permit continual work in rooms where concentrations higher than that level are detected.

In order to work with safety, rooms where products such as perchloroethylene, trichloroethane or other similar cleaning liquids are used need to be well ventilated and, if it is not possible to have natural ventilation, then they must be fitted with autonomous systems for extraction and air renovation, these systems being unable to be connected to the general acclimatisation of the building.

Chemical cleaning machines have to be hermetic, they must have gas condensation systems for the recovery of the cleaning liquid and be located in areas that are ventilated and isolated from work zones by means of enclosures permitting the functioning of the machines to be controlled from outside.

In order to enter spaces where the machines are located and carry out manual cleaning, it is essential to use full protection masks and gloves.

If a worker accidentally becomes intoxicated by these products, he or she must be provided with immediate medical care and, in the meantime, be placed in a well ventilated zone, given oxygen and, if necessary, artificial respiration.

The storage of cleaning products must be done in metallic safety receptacles, with labels specifying their content, and in cool places fitted with fire detection and extinction systems. Although, as has been stated, these products do not give off poisonous gases, some of them can produce these due to reaction under the action of intense fire.

Most cleaning products harm the ozone layer. Some, such as 1.1.1.trichloroethane (1.1.1.TCE), have not been totally banned, and the use of trichloroethylene and of perchloroethylene is subject to growing restrictions for this same reason.

In many countries, it is not permitted to discard these products by pouring them down the drain. Waste products have to be collected by the user in the same drums as they were acquired, and handed over to the municipal services for or regeneration.

Textual Note I

Catalina, Fernando (Instituto de Ciencia yTecnología de Polímeros - C.S.I.C): "Soportes cinematográficos basados en triacetato de celulosa". In: Los soportes de la cinematografía, Filmoteca Española, Madrid, 1999.

Comparative table of some of the properties of the three plastics

PROPERTY	Nitrate	Triacetate	Polyester
Tensile strength (kg/cm^2)	680-750	612-1088	1160-1700
Elongation to breaking point (%)	30-40	10-40	70-130
Resistance to tearing (Kg/cm^2)	------	3'7-26'9	33'7
Absorption of moisture (24hours at 20ºC)	1'5-2	3'5-4'5	0'8 (168h. at 25ºC)
Gas permeability	high	high	very low
Inflammability	very high	slow	very low
Resistance to acids and alkalis	low	low	they do not attack it
Resistance to microorganisms	------	depending on plasticiser	very good

Textual Note II

Tristsmans, R.G. (Ingénieur en Chef à la S.A. Photo-Produits Gevaert): "Le nouveau support des films cinématographiques Gevaert". In: Le Cinéservice Gevaert, feuille Q/110, Mortsel, May 1949.

Tables of characteristics extracted from the text referenced.

PROPERTIES OF THE PLASTICS USED AS CINEMATOGRAPHIC SUPPORTS				
	Nitrate	Diacetate	Triacetate	Aceto-Butyrate
Mechanical strength				
Tensile strength (in Kg/mm^2)	11'5	9	11	10'5
Elongation to breaking point (%)	40	32	30	37
Susceptibility to water				
Absorption of water (%)	1'5	6	3	2'5
Lengthwise elongation (‰)	5	14	7	5
Loss in weight and contraction (after 5 hours at 80ºC)				
Loss in weight (%)	2	2'2	2'2	2
Contraction (‰)	4'5	3'5	3	2'5
Ageing in normal conditions of maintenance (tensile strength)				
Immediately following manufacture	11'5	9	11	10'5
After 6 months	12	9	11	11
After 12 months	12'5	9	11'5	11
(elongation to breaking point)				
Immediately following manufacture	40	32	30	37
After 6 months	36	32	30	37
After 12 months	33	33	30	37

Textual Note III

Eastman Kodak Co.: "Storage and Preservation of Motion Picture Film". Motion Picture Film Department, Rochester, 1957. pp.47

Table VI Atmospheric Conditions Recommended for Storage of Processed Motion-Picture Films				
Film Classification	Commercial Storage		Archival Storage	
	Temp. F	R.H., %	Temp. F	R.H., %
Acetate Film				
Black-and-White	Below 80	25 - 60	60 - 80	40 - 50
Colour	Below 80	25 - 60	Below 0	15 - 25
Nitrate Film				
Black-and-White	Below 70	25 - 60	Below 50	40 - 50
Colour	Below 80	25 - 60	Below 0	40 - 50
Note: Some colour films and nitrate films may be considered of archival value, even though these materials are not recommended for permanence record use.				

Textual Note IV

Amo, Alfonso del: (Filmoteca Española) "Caracteristicas y posibilidades de conservación". In: Los soportes de la cinematografía, Filmoteca Española, Madrid, 1999. pp 17

Table 3 – Initial results. The thicknesses of the films

Sample	1K	2K	3K	4 D	5 K	6 K	7 D	8 D	9 A
Film	134	137	139	143	134	141	143	142	131
Support	122.1	126.4	130	129	124.4	129.7	129	127.3	119.2
Emulsion	11.9	10.6	9	14	9.6	11.3	14	14.7	11.8
Sample	10 I	11 D	12 I	13 A	14 A	15 K	16 V	17K	18 E
Film	136	134	135	136	134	135	137	133	137
Support	131.7	121	125.2	124.4	120	126.5	125.8	124.8	124.7
Emulsion	5.3	13	9.8	11.6	14	8.5	10.2	8.2	12.3
Sample	19 K	20 K	21 N	22 K	23 K	24 ?	25 A	26 A	27 A
Film	129	131	129	140	130	135	121	128	129
Support	120.5	123.4	119.7	132.5	122.7	128.4	117.3	121.4	121.7
Emulsion	8.5	7.6	9.3	7.5	7.3	6.6	3.7	6.6	7.3
Sample	28 A	29 A	30 A	31 ?	32 A	33 A			
Film	128	131	130	128	133	133			
Support	122.4	123.8	121.3	121.4	124.8	126.3			
Emulsion	5.4	7.2	8.7	6.6	8.2	6.7			

The measurement of the total thickness of the samples experienced very significant variations.
- Between the143 micra of sample 4 and (disregarding sample 25 whose details may have an error of transcription) the 128 micra shown by several samples, there was a difference of 15 micra, which represented a 10.5% difference in thickness.
The thickness of the films appeared to drop as these became more modern.
- The average thickness of the first 9 samples was138.2 micra; in the following 9, the average was 135.2; in the samples in the third line (omitting 25) it was 131.3 and in the last six samples,130.5.
If only the thicknesses of the supports are taken into account.
- The difference between the *samples nı 22 and nı 9 represents 10.3% of the thickness.*
- The average thickness drops in very similar proportions: 127.5, 124.9, 123.8 and 123.3.
With respect to the emulsions, the differences are much greater, with emulsions of more than double the thickness of others.
- Although there is no relationship between the thicknesses of the emulsions and of the supports, there is also a drop in the average thickness in the emulsions as the date of manufacture advances (11.9, 10.3, 7.6 and 7.1, in the four groups of the table) similar to that of the supports

Textual Note V

Bigourdan, Jean-Louis (Image Permanence Institute. Rochester Institute of Technology): "Preservation of Acetate Base Motion-Picture Film: From Stability Studies to Film Preservation in Practice". In: The Vinegar Syndrome. Gamma Group - Association des Cinémathèques Européennes, Bologna, 2000. pp 16

Table II: Major manifestations of vinegar syndrome

Manifestations of decay	Comments
Acidity	First sign of acetate decay. Requires either testing on site with acid-detectors or laboratory testing.
Vinegar odour	Obvious sign of vinegar syndrome. Results from the deacetylation of the polymer. Acidic vapours can cause health problems.
Shrinkage	Shrinkage can result from solvent loss. However, destructive shrinkage is caused by chemical decay. Shrinkage can be measured and will affect the possibility of duplication. Extreme shrinkage can cause the delamination of the image layer of the film.
Embrittlement	The shortening of polymer chains affects physical properties and makes the polymer brittle. This creates handling hazards.
Crystals or bubbles	Crystal's deposits or bubbles observed on the film surface are evidence that additives to the polymer (plasticizers) have become incompatible with the decaying polymer.
Emulsion softening	Although acetic acid is a weak acid, in high concentrations it can cause gelatin binder to soften. (Degrading nitrate releases a strong acid, and gelatin decomposition is common in nitrate collections.)
Base discoloration	Generally, decaying acetate base does not become discoloured. (Decaying nitrate discolours.)
Dye fading	Dyes fade spontaneously depending on temperature and humidity. Acidic byproducts of acetate base decay promote further dye fading.
Silver oxidation	Acetate degradation byproducts are not oxidizing compounds, and they don't cause silver image oxidation. (Degrading nitrate releases strong oxidizing compounds that oxidize the silver image.)

Textual Note VI

Eric Lone (Département Catalogage-Analyse du Service des Archives du Film, C.N.C.) "La manufactura de película en Francia antes de 1929". Published in the periodical "Archives" no. 32 - Filmoteca de la Generalitat Valenciana, Valencia, June 1999 - pp 84 to 93.

The film ozaphane was exploited by the company Cinelux. It is a strip of non-combustible cellophane 40 micra thick that has no emulsion, but rather its mass is the sensitive element. Its print is made by contact with a positive and the developing is performed in a case by means of ammoniated gases. It offers the advantage of limiting the risks of scratching and of obtaining very light reels (a 2000-metre feature film can fit on a single reel). Its cost was on an average less than celluloid film. Its other particularity was that it had no sprocket holes, being shown through a special projector without sprockets or Geneva wheels. In general, the ozaphone film was presented on strips 24 mm wide, however, in 1931, a 35 mm film was also marketed, including with a sound track.

Textual Note VII

Dr. Hubertus Pietrzok: "Historical development and properties of the colour photographic material used in cinematography". In: "Preservation and restoration of moving images and sound" - Chapter 4, pp.: 19 to 59. FIAF, Brussels, 1986.

4.3.5 - The quality of colour reproduction

The description which we have given so far of additive and subtractive systems is a simplified and idealized account of what takes place during colour analysis and synthesis. In practice the use of three colours in the analysis and synthesis of colours in the original has certain limitations, especially with regard to accurate colour reproduction. The limitation stems, among other things, from:

a) the characteristic of the dyes used during the process and in the final picture;
b) the characteristics of the system used to analyse the colours of the original object, and to modulate the colours during reproduction;
c) the fundamental difficulties of obtaining a good colour balance using primary colours.

The limitations do not invalidate the principles of colour reproduction through the various processes nor prevent colour photographers from producing perfectly acceptable colour pictures if they keep to the processes recommended by the manufacturers. Methods of improving colour reproduction involve highly developed processes of colour control and correction, but are more of an elaboration than a modification of the principles of colour reproduction.

Textual Note VIII

Manuel Recuero López: "Técnicas de grabación sonora - 2". ("Two-Inch Sound Recording Techniques") Instituto Oficial de Radio y Televisión (Official Radio and Television Institute), Madrid, 1988. pp. 100.

Table 7.5 - Tape Length, Speeds and Operating Time

SPEED (CENTIMETRES/SECOND)								
Length (m)	High Speeds				Medium Speeds		Low Speeds	
	305	152	76.2	38.1	19.05	9.52	4.76	2.38
2.926	16'	32'	1h4'	2h7'30"	4h15'	8h30'	17h	34h
2.194	12'	24'	38'	1h36'	3h12'	6h24'	12h48'	25h36'
1.463	8'	16'	32'	1h4'	2h7'30"	4h15'	8h30'	15h
1.097	6'	12'	24'	48'	1h36'	3h12'	6h24'	12h48'
731	4'	8'	16'	32'	1h4'	2h7'30"	4h15'	8h30'
549	3'	6'	12'	24'	48'	1h36'	3h12'	6h24'
366	2'	4'	8'	16'	32'	1h4'	2h7'30"	4h15'
274	1'30"	3'	6'	12'	24'	48'	1h36'	3h12'
183	1'	2'	4'	8'	16'	32'	1h4'	2h7'30"
137	45"	1'30"	3'	6'	12'	24'	48'	1h36'
91	30"	1'	2'	4'	8'	16'	32'	1h4'
68	22½"	45"	1'30"	3'	6'	12'	24'	48'
46	15"	30"	1'	2'	4'	8'	16'	32'

LENGTH OF TAPE HOUSED IN STANDARD-SIZED CASSETTES							
Tape Type and Approximate Thickness		Roll Diameter (cm)					
		7'62	10'16	12'7	17'78	26'67	35'56
Standard	50.8µm	45.72m	91.44m	182.88m	366.76m	731.52m	1.463.04m
Fine	38.1µm	68.58m	137.16m	274.32m	548.64m	1.097.28m	2.197.56m
Superfine	25.4µm	91.44m	182.88m	366.76m	731.52m	1.463.04m	2.962.08m

Textual Note IX

Alfonso del Amo García: "Inspección técnica de materiales en el archivo de una filmoteca" ("Technical Inspection of Stocks at a Film Archive"). Filmoteca Española, Madrid, 1996. P. 88-91

Image Area and Format Dimensions and Proportions

The measurements given are based on the ASA and ISO standardisations due to minor differences being entailed.

FORMAT AND NOMINAL PROPORTIONS		CAMERA		PROJECTION	
		Distance from image to edge in question	Filmed image surface area	Projected image area	Proportions
35mm	SILENT (1) 1.33	----------	18.00 / 24.00	17.25 / 23.00	1.33
	Standard (2) (a) 1.37	(b) 18.75	16.03 / 22.05	15.25 / 20.96	1.37
	Standard (3) 1.37	(c) 7.80	16.00 / 21.95	15.29 / 21.11	1.37
35mm	Widescreen (2) 1.85	(b) 18.75	(4) / 22.05	11.33 / 20.96	1.85
	1.75	(b) 18.75	(4) / 22.05	11.96 / 20.96	1.75
	1.66	(b) 18.75	(4) / 22.05	12.62 / 20.96	1.66
	(3) 1.85	(c) 7.80	(4) / 21.95	11.33 / 21.11	1.86
	1.75	(c) 7.80	(4) / 21.95	11.96 / 21.11	1.76
	1.66	(c) 7.80	(4) / 21.95	12.62 / 21.11	1.67
	Vistavision (5) 1.75	---------	22.1 / 37.52	21.31 / 37.29	1.75
	Cinerama (6)	---------	----------	27.64 / 75.06	2.71
35mm	CinemaScope (mag sound) (2) 2.55	(b) 17.50	18.67 / 3.80	18.16/23.16	(d) 2.55
	CinemaScope (opt sound) (2) 2.35	(b) 18.75	18.67 / 22.10	18.16 / 21.31	(d) 2.34
	"Scope" (3) 2.35	(c) 7.80	18.60 / 21.95	18.21 / 21.29	(d) 2.34
	Technirama (5) 2.35	---------	23.80 / 37.15	18.16 / 21.31	(e) 2.34
	Techniscope (5) 2.35	---------	9.34 / 22.10	18.16 / 21.31	(f) 2.34
16mm	(2) 1.33	(b) 7.97	7.49 / 10.26	7.21 / 9.65	1.33
	(3) (g) 1.33	(c) 2.95	7.42 / 10.05	7.26 / 9.65	1.32
	S16mm (3) (h) 1.66	(c) 2.95	7.42 / 12.52	----------	---------
70mm	70mm (3) 2.20	(c) 6.24	23.00 / 52.50	----------	---------
	65mm (3) 2.20	(b) 34.95	23.00 / 52.60	22.00 / 48.60	2.21
	70mm (2) 2.20	(c) 8.73	23.00 / 52.50	22.10 / 48.59	2.20
8mm	D-8 (3) 1.33	(b) 5.21	3.60 / 4.90	3.40 / 4.55	1.33
	S8 (3) 1.37	(b) 4.32	4.22 / 5.69	4.01 / 5.46	1.36

(1) Dimensions not standardised, not even as reference.
(2) Adhering to ASA standards
(3) Adhering to ISO standards
(4) Dimension not standardised for negative, not even as reference.
(5) Dimensions not standardised.
(6) For three-support Cinerama (plus a fourth support for the eight sound tracks), the image was incorporated onto three 27.64 / 25.02 frames (on 5 perforations). The actual projection format (!:2.71) was masked by the screen curvature, which lessened the viewing proportions to 1: 2.2.
(a) The standardised dimensions for negatives and copies were those of the Movietone format, which has a 1.37 proportion.
(b) Between edge in question and the image area axis.
(c) Between the edge in question and the edge of the image area.
(d) Image deanamorphised on screen.
(e) The dimension given is solely as a reference
(h) 16mm type "W".

Textual Note IX (bis)

Sound Column Dimensions and Proportions

Measurements based on the standardisations issued by the International Standard Organisation (ISO)

GAUGE & SYSTEM		From axis to reference edge	Sound area	Sound column	Area scanned
35mm	Variable area	6.30	2.99	1.93	2.13
	Variable density	6.30	2.99	2.54	2.13
	Mag. scope (on) Track 1	1.02	----------	1.60	1.27
	Track 2	5.36	----------	1.60	1.27
	Track 3	20.18	----------	0.97	0.635
	Track 4	33.99	----------	1.60	1.27
	Sep-Mag 3 Tracks Track 1	8.60	----------	5.00	----------
	Track 2	17.50	----------	5.00	----------
	Track 3	26.40	----------	5.00	----------
	Sep-Mag 4 Tracks Track 1	7.90	----------	3.80	----------
	Track 2	14.30	----------	3.80	----------
	Track 3	20.70	----------	3.80	----------
	Track 4	27.10	----------	3.80	----------
16mm	Variable area	1.48	2.95	1.52	1.80
	Variable density	1.48	2.95	2.03	1.80
	Magnetic (1)	14.55	2.95	2.55	2.15 (2)
70mm	Magnetic(b)Track 1	1.42	----------	4.80 (3)	1.25
	Track 2	4.22	----------	----------	1.25
	Track 3	9.47	----------	0.80	1.25
	Track 4	60.52	----------	0.80	1.25
	Track 5	65.77	----------	----------	1.25
	Track 6	68.5		4.80	1.25
8mm	Magnetic	0.40	0.90	0.67	0.48 (2)
S8mm	Optical	7.57	----------	0.50 (4)	0.66
	Magnetic (1)	7.58	----------	0.68	0.53 (2)

(1) The 16mm and S8 format films with magnetic sound may have another track adhered to balance the winding. This track, located between the perforations and the edge, is not used for sound recording purposes.
(2) The scanning or universal head gap size.
(3) Sound tracks 1-2 and 5-6 go on one same magnetic track.
(4) Width of the modulated area. The recorded area may be max. 0.75.
(a) Relationship between tracks and theatre speakers: Track 1, left. Track 2, centre. Track 3, control or auditorium. Track 4, right. There was a magneto-optical copy variation, with an optical sound track measuring 0.97mm in width located between Track 2 and the image.
(b) Relationships between the tracks and the theatre: Track 1, left of screen. Track 2, left centre. Track 3, centre. Track 4, right centre. Track 5, right of the screen. Track 6, ambience or control signals.

Textual Note X

Alfonso del Amo García: "Inspección técnica de películas en el archivo de una filmoteca" ("Technical Inspection of Stocks at Film Archive "). Filmoteca Española (Spanish Film Archive), Madrid, 1996. P. 141.

IMAGE SCREENED IN SEVERAL GAUGES AND FORMATS		
Gauge & Format	Surface Area	Proportion (35mm academy = 1)
70mm	1069 mm2	3.31
35mm (silent)	396 mm2	1.22
35mm (scope)	388 mm2 (*)	1.20
35mm (standard	323 mm2	1
35mm (panoramic 1.66	265 mm2	0.79
35mm (panoramic 1.75)	251 mm2	0.77
35mm (panoramic 1.85)	237 mm2	0.73
16mm	70 mm2	0.21

(*)Surface area of the anamorphised frame.

This table, prepared by the author stated above, is based on an idea set out in "La Enciclopedia Focal" ("The Focal Encyclopaedia") in the article: "Película, características físicas y dimensiones" ("Film, Physical Characteristics and Dimensions")

Nota Textual XI

El rollo primero de Carmen la de Triana / Andalusische Nächte, coproducción Hispano-Alemana de 1938, pudo reconstruirse por completo gracias a la localización de una copia muy tardía, en soporte de triacetato, que siempre fue proyectada en rollos dobles.

(Extractado del informe de reconstrucción)

De esta película se han recuperado tres copias de proyección (dos de las cuales fueron utilizadas en la reconstrucción de este rollo) y un duplicado negativo en nitrato cuyo primer rollo está gravemente afectado por la descomposición química, que avanza desde el inicio hacia el final del rollo y que ha dañado o destruido total o parcialmente imagen y sonido, no obstante este material conserva íntegra toda su longitud original.

CARMEN LA DE TRIANA - ROLLO PRIMERO		
CONTENIDO	primer fotograma de la sección en reconstrucción	material utilizado en la reconstrucción
Cola sonora de entrada	0	Duplicado Negativo Nitrato
Cabecera	1004	Duplicado Negativo Nitrato
Planos 1 y 2	3708	Duplicado Negativo Nitrato
Planos 3 a 40	5233	Copia de proyección Nitrato
Planos 41 a 44	12459	Copia de proyección Safety
TOTAL	13758 fotogramas = 9’33” 8 f.	

La copia safety presenta todo tipo de lesiones uso producidas a través de múltiples proyecciones (posiblemente realizadas en equipos muy descuidados) no obstante es la única que conserva, prácticamente íntegros, los cuatro últimos planos del rollo.

Textual Note XII – Filmoteca Española Inspection Report Form.

This form is a simulation provided to serve as a guide in the development of the Database created for handling the Film Collection. Data from an actual report has been filled in on this form, characterising said data using the pertinent codes for each field.

[FRONT SIDE]

SOURCE

Type 06 LABORATORY PURCHASE	**Date received: 10-12-98**	**Receipt Code: 98000557**
Source: FOTOFILM MADRID		
Title upon receipt: SIERRA DE TERUEL		**Reference:**
Technical source: Reproduced from N-2457 (Image dupe negative + Sound negative)		

FILM IDENTIFICATION AND REASON FOR INSPECTION

Main title: SIERRA DE TERUEL					**PIC No.:** 0250--0133785--0
Produced by: Propaganda Department/Ministry of the Interior/ Corlignion-Molinier Productions					**File No.:** 17892
Director(s): André Malraux					
Actors: Jorge Sempere / Andrés Mejuto / Julio Peña					**Year: 1939**
Nationality (ies): Spanish - French					**Length: 75 minutes**
Image System 01	**Emulsio n 01**	**Sound 02**	**Gauge 01**	**Format 02**	
CONSERVATION 02	**Reason for report 03** Archive acceptance inspection and check				

STOCK AND VERSION IDENTIFICATION

ARCHIVE NUMBER **05-35-05327**	BOXES **04**	**Stock Type** **22 STANDARD COPY** / **Relationship to motion picture** **01 MOTION PICTURE**			
Version **15** Language: **01** Spanish	Medium:	Gauge:	Format:	Emulsion:	TC:
Title on stock: SIERRA DE TERUEL		**Length: 2030'8m**		**Duration: 75 min.**	
Remarks: Original version restored from the standard copy conserved at the MOMA. Includes Title in English inserted at the time by the MOMA and the header of the French distributor.					

TECHNICAL CHARACTERISTICS OF THE STOCK

Support **03** Triacetate	Gauge **01** 35mm	Perforations: **P**	Format **03** Standard	A. Ratio: **1: 1'37**
Emulsion **01** Black and White	Sound **02**	Sound system **05** Symmetrical, single-track variable area		
Image/Sound ratio **01**	Brand of stock: **EASTMAN X¯** ¶			
Remarks: Fourth-generation standard copy. The second-generation positive was a standard copy on nitrate support.				

STOCK'S CONSERVATION

SUPPORT - General condition: **NEW FROM LABORATORY**		
Chemical Condition **01** Good Condition	Contraction **01** Good Condition	Color
Stains **01** Good Condition	Perforations **01** Good Condition	Scratches **01** Good Condition
Breaks **01** None	Contamination **01** None	Detachments **01** None
Remarks con CONDITION		

CONTINUITY - General condition: **COMPLETE**

This version includes a Title incorporated by the MOMA with explanations as to source and political bearing of the film. It also includes the sign of the distributor: "Compagnie Continentale Cinématographique". This version is longer than the version premiered in Spain.

REPRODUCTION

Stability: IMAGE [01] SOUND [01] Good overall quality

IMAGE Reproduction [01] Good reproduction quality. Some very limited photographed damage.

SOUND Reproduction [01All available sources having been compared, this sound is the finest-quality conserved.

USE

CONDITION and USE Criteria Made from the image Dupe-Negative and from the sound Dupe-Negative, which were reversed with one another. The image Dupe-Negative has the combined sound, but this copy has been made from the separate sound-Dupe. This is the only standard copy reproduced from this source.	USE **06 EXCLUSIVE ARCHIVE COPY**
Date: January 26,2000	Inspected by: Alfonso del Amo

THEME-BASED CATALOGUING SUMMARY OR DATA
FICTION; SPANISH CIVIL WAR; AVIATION; INTERNATIONAL BRIGADES;
First months of the Spanish Civil War. An aeroplane in flames returns to its base on the Aragon front, the aviators get out of the plane carrying the corpse of a fellow aviator. In the field headquarters, Commander Peña says a few words in homage to the deceased aviator of Italian descent who was the squadron's political commissar. Later, Peña and Captain Muñoz discuss the situation at hand. A bridge used by the enemy to get reinforcements must be bombed. The obvious arrival of new planes to the fascist aviation corps has made this mission almost impossible, and when they are getting ready to leave, a call from their superior will call off the operation. Muñoz laments the fact, but Peña explains that it is necessary to trust in the actions of the partisans, who, to halt the forward movement of the enemy, have roused several towns to rebellion in the rearguard. In Teruel, the partisans meet in the back room of a drysaltery. The advance of the enemy reinforcements has been halted, but the towns which have rebelled, especially Linás, which controls a narrow pass, need urgent help. It is absolutely essential for reinforcements to be sent, but there are almost no weapons available. Two militiamen come in with a bag full of handguns and ammunition. The weapons are handed out, and the men get read to move out: They are going to break through the pass through the gate in the wall surrounding the town. When the reach the wall, the partisans find that there is a cannon guarding the gate and decide to attack it by running an automobile into it. Carral and a driver grab a vehicle and destroy the cannon, both dying in the crash. The partisans manage to get out. In Linás, José, a peasant, has discovered the location of a new field aerodrome of the fascists. He talks to the Committee, requesting a guide to cross the line of fire to inform the republican aviation corps. The partisans from Teruel arrive in Linás and organise an attack using dynamite bombs, requesting metal containers for making the bombs. The inhabitants of Linás respond to the call, queuing up with the greatest mix-mash of objects, everything from huge electric lightbulbs to a safe. The partisans, led by a miner from Asturias, select the containers and go off with the bombs loaded in a wheelbarrow. José and the peasant guiding him come to a town under enemy control and contact a tavernkeeper to ask for information, but the tavernkeeper betrays them by shooting at the guide. José kills the tavernkeeper and manages to escape, crossing the lines and making his way to the aerodrome. In the office of the republican chief of aviation, José tries to report on the location of the aviation field he has discovered, but he knows nothing about maps and is not able to pinpoint the exact location of the field on the map, offering to go up in a plane to point out the location of the field right from the air. The Commander takes Jose's information as good and decides that the attack can only successfully go undetected by the enemy by using the tactic of surprise and arriving at dawn. They will attack the aviation field first and then the bridge. To attack at dawn, the planes have to take off at night, and to do so they will need spotlights to light the runway. The commander and the new political commissar go through the nearby towns asking for automobiles to light the runway using their headlights. Overcoming their own difficulties, the committees of the towns decide to furnish their help and, at the appointed time, twelve automobiles show up and are stationed at the end of the field. The aeroplanes take off. At dawn, they are five minutes away from the target, but the clouds and the way the ground looks from the air throw the peasant off, and he is not able to recognise the location on land. The aeroplanes drop down to 300 meters and, at last, José finally points out the field. The surprise bombing hits the mark. The aeroplanes change course and attack the bridge, which is destroyed. The enemy fighter plane appears. Several aviators are injured and one plane is seriously damaged in the ensuring combat. The arrival of the republican fighter plane makes the fascists flee. On the return flight, the damaged aeroplane is unable to gain sufficient altitude to make it over the mountains and crashes. From the aerodrome, the commander organises the search for the missing aircraft, managing to get information by telephone as to the exact location where the plane went down, near a town in the mountains, calling on the inhabitants to help the aviators. The peasants carry the injured and dead down in their arms, on stretchers and on mules. Little by little, the inhabitants of all of the towns in the region form a cortege on either side of the procession, which, by the time the commander catches up with the procession, runs the full length of the valley. As the entire town comes down from the mountains accompanying with volunteers who are fighting for freedom, the commander explains the nationality of each one of the aviators to a women.

Roll No.	NOTES AND CONDITION BY ROLLS	Length / Duration
Roll 1	Contains rolls 1 and 2 of the film.	310'7 + 264.5 = **575.2** 11'19" + 9'38" = **20'57"**
Roll 2	Contains rolls 3 and 4 of the film.	260'7 + 288.1 = **548.8** 9'30" + 10'30" = **21'**
Roll 3	Contains rolls 5 and 6 of the film.	257.5 + 223.4 = **480.9** 9'23" + 8'8" = **17'31"**
Roll 4	Contains rolls 7 and 8 of the film.	287.8 + 138.1 = **425.9** 10'29" + 5'2" = **15'31"**
TOTAL LENGTH / DURATION		**2030.8 meters / 75 minutes**

Textual Note XIII

Henning Schou, Harold Brown et al: "Preservation of Moving Images and Sound". FIAF Preservation Commission, Brussels, 1990.
Summary of : Page 34. Tables 6.1 and 6.2

EFFECT OF THE TEMPERATURE ON THE STABILITY OF THE DYES OF THE IMAGE			
Temperature of stockage	Relative duration of stockage	Temperature of stockage	Relative duration of stockage
30ºC (86ºF)	1/2	4ºC (39ºF)	16
24ºC (75ºF)	1	-18ºC (0ºF)	340
19ºC (13ºF)	2	-26ºC (-15ºF)	1000
13ºC (55ºF)	4	----------	----------

EFFECTS OF THE HUMIDITY ON THE STABILITY OF THE DYES OF THE IMAGE			
Relative humidity %	60	40	15
Relative duration of stockage	1/2	1	2

Textual Note XIV

J.L. Bigourdan and J.M. Reilly (Image Permanence Institute): "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome: Preservation Strategies for Acetate Base Motion-Picture Film Collections". In: Joint Technical Symposium. "Les enjeux du 3ème millénaire". C.S.T. - C.N.C., Paris 2000. Pp. 14 to 34.
Table III: Benefit of macro environmental control. Effect of temperature and relative humidity on further CTA chemical decay from acidity of 0.5 to 1.0. Predictions based on accelerated aging. Approximate time factor of improvement versus temperature and RH.

Temperature	Time Factor at 50% RH	Time Factor at 20% RH
35ºC	1	3
25ºC	3	15
15ºC	10	45
5ºC	45	200
-1ºC	110	540

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