Vinegar Syndrome: An Action Plan

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THE CURRENT SITUATION

Fifty years after the replacement of nitrate by triacetate film base, motion-picture film archives are facing another preservation challenge. Today it is likely that most archives are affected by vinegar syndrome. It is widely recognized that acetate base film is inherently unstable. Many institutions, however, may not have given sufficient attention to the problem of preserving their acetate film collections for the future.

Triacetate film base, like nitrate, is a chemically unstable support. Both are subject to spontaneous decay, which shortens the life expectancy of photographic film. Paradoxically, nitrate film collections had the advantage of being perceived as so unstable, and so dangerous because their flammability, that large-scale nitrate preservation programs have been undertaken worldwide during the past several decades. These efforts have focused on duplication and safer storage, with the goal of preserving the content of the still existing works on cellulose nitrate base. Film archives began making copies of nitrate films on cellulose triacetate base, which was perceived as a safe medium for the preservation of disappearing nitrate collections. We know now that this might have been the case if the acetate copies had been stored properly. Data indicate that freshly processed acetate base film can last for several centuries in cold storage. Under adverse storage conditions, however, acetate base decay has been observed after only a few years. It is unfortunate that the importance of proper storage was not understood and recognized early enough to be made a priority in film archives policy. In fact, it is only during the past fifteen years that a number of large-scale research projects have focused on film base stability. The periodic revision of standards[1, 2] recommendations has integrated the findings of these projects and reflects the evolution in the field. Despite archivists' efforts and dedication, film collections have rarely benefited from optimum storage conditions. Consequently, most acetate collections are affected by the vinegar syndrome and may be decaying at an unacceptable rate.

Today, vinegar syndrome is a critical issue that must be re-examined by practitioners in the field of film preservation. One reason for this is that photographic film on triacetate base represents the major portion of motion-picture collections. Another is that evidence shows that base decay is common throughout film collections, a situation that is cause for growing concern in the film archives community. The main goal of this paper is to propose a methodology for approaching the vinegar syndrome problem. The principles of this approach are discussed in "Preservation of Acetate Base Motion-Picture Film: From Stability Studies to Film Preservation in Practice" in this publication. The same information is presented here in table format as a series of decision criteria, which, taken together, articulate a proactive strategy based upon two fundamentals: (1) evaluation of the condition of film collections, and (2) assessment of storage conditions. These actions must be taken if we are to have future access to our acetate film collections. The reader may refer first to Figure 1, which gives an overview of the recommended action plan. Figure 1 indicates priorities and serves as a key to Tables II and III. These tables explain why these actions are important, how they can be achieved, and what follow-up steps should be taken.

THE CONDITION SURVEY: EVALUATING THE STATE OF PRESERVATION OF ACETATE COLLECTIONS

The acetate film in any sizable collection can usually be broken down into four categories (see Table I). Films in the first category (i.e., *good* or *fair* condition) can last several centuries in proper storage. Films in the second and third categories can last long enough to be duplicated if kept in adequate storage. If the *damaged* films in the fourth category are not treated using special duplication or restoration techniques, they will be lost. The preservation options presented in Table I reveal that proper storage is an effective option for film preservation. Cold storage optimizes the chemical stability of photographic film, postpones further decay, and stabilizes film in critical condition. Therefore, knowing the distribution of film conditions within a collection is an essential step for film archivists.

Table I: Film conditions that can be observed in collections

Film condition category	Characteristics	Preservation options
Good or fair	Films are not decaying, or are just starting to decay	Films can last a century at cool temperature and several centuries if kept in cold storage.
Actively decaying	Film may decay at a fast pace depending on storage conditions.	Films can last a century in cold storage
Critical	Films are still usable. However, shrinkage and warping are imminent.	Films can be stabilized in cold storage while awaiting duplication.
Damaged	Films display various degrees of shrinkage and other extreme manifestations of decay.	Current restoration procedures may not be able to save these films. Digital techniques will extend restoration possibilities.

While obvious manifestations of vinegar syndrome (e.g., vinegar odor, shrinkage, warping, plasticizer deposits) have been observed in archives for a long time, only recently have sensitive and easy-to-use survey tools[3,4] been developed that will (1) detect decay at an early stage before other changes are noticeable, and (2) accurately quantify film condition. Determining the state of preservation of acetate base collections with these new tools enables archivists to make *proactive* preservation decisions.

Recently, some archives have undertaken extensive condition surveys using such tools, one of which is A-D Strips.[3] Archivists should be prepared to act on their survey results, however, because this new approach may unveil an even darker picture of the vinegar syndrome problem than they imagined. The bad news could be that the whole collection is decaying. The good news is that archivists now have a way to clearly describe the problem, identify groups of vulnerable materials, base their need for funding on hard evidence, and choose the best-fit preservation strategy for their collection.

Once the survey tool has been chosen, the next phase in planning a condition survey is to determine a sampling method. How many items have to be tested? Which items have to be tested? Statistical sampling is the best method for surveying large collections. Testing item-by-item requires substantial staff and time. A practical approach for surveying a motion-picture film collection is described in “The Use of a Statistical Approach to Evaluate Accurately the Spread of the Vinegar Syndrome in a Large Collection.”[5] A survey is also a good opportunity to record additional information about the collection (e.g., date of manufacture, type of materials, special film treatment, and brands). Such information may be useful for data analysis and to reinforce anecdotal evidence. Results obtained from one condition survey, for example, indicated that prints with magnetic sound tracks were generally in poorer condition than prints with optical sound tracks.[5] There is no doubt that such data have great value and that field observations are essential for finding new directions for research in preservation science.

It is unlikely, however, that this type of information will change the general approach to the control of vinegar syndrome. It has been demonstrated that the only way to effectively minimize the decay of acetate collections is to provide suitable storage conditions. The urgency for implementing colder storage temperatures is dictated by the current condition of the film. Once this has been determined, the question “What should happen next?” can be answered, following the guidelines laid out in Table II. For example, if a collection contained films with advanced decay, the next step would be stabilization.

Stabilize film in advanced state of decay

The use of cold or subfreezing storage temperatures can postpone further decay of film in critical condition (for example, films at level 2 and 3, if A-D Strips are used for testing). Films in this condition may still be usable and may not display excessive shrinkage or warping; duplication is still possible. Placing these films in cold storage drastically reduces the rate of further chemical changes, thereby stabilizing them until they can be duplicated. (Kept in cold storage, a film at level 2 can last several decades before the end of its useful life.) While these films are stabilized at low temperatures, a plan for duplicating them should be established. Film should be prioritized for duplication based on its condition and on the funding resources and staff available.

Minimize the risk of contamination

Since vinegar syndrome is infectious, its presence signals the need to minimize contamination of undegraded films by degradation byproducts from decaying films. This problem can be addressed in two ways: by removing the degradation byproducts from the storage space, or by segregating the decaying films. The first option can be implemented by controlling the quality of the air in the whole storage area. Increasing air exchange, using activated charcoal and molecular sieves filters, and installing filtration systems using alkaline compounds are among the ways to reduce the concentration of acidic vapors in the storage vault. This macroenvironmental approach is the most suitable solution for large film collections. The second option requires the use of individual sealed microenvironments or a separate space that can accommodate a number of films. Adsorbents (e.g. molecular sieves)[6] added to sealed enclosures benefit film stability somewhat by scavenging some of the acidic degradation byproducts (their primary contribution is reducing the moisture content in the film).

As a rule, however, minimizing the risk of contamination is not enough to ensure the future of the collection. Decaying films require lower temperatures to last.

Prioritize films for duplication

Duplication has been an essential part of preserving motion-picture film collections for many years. The cost of duplication is high, however, and more often than not, institutional resources are limited. Plus, the prevalent “wait, then duplicate everything” approach is impractical, if not impossible. It has been demonstrated that film, even decaying film, can last a long time if kept in proper storage. It is also true that the more advanced the chemical decay is, the more likely it is the film is approaching the end of its life. Therefore, it makes sense to use the information gathered from the condition survey to determine which films are most at risk and to duplicate them first. These are films that test at A-D Strip level 2 and level 3. Since duplication alone will solve the problem for only a limited number of films, such a program should be backed up by improved storage conditions. Using cold storage temperatures will stabilize film awaiting duplication and will reduce the need for an urgent and large-scale duplication program.

Monitor the condition of the collection

Since acetate base decay is a continuing chemical process, film condition should be monitored periodically. If this is done, rational and timely decisions can be made and widespread losses can be prevented. Monitoring frequency should be based on (1) results obtained from the initial condition survey, and (2) existing storage conditions. The goal is to keep the film from becoming damaged before proactive measures can been taken.

For example, an actively decaying film at A-D Strip level 1.5, stored near or at room conditions, may reach critical condition (A-D Strip level 2) within five years. The same film kept in cold storage (e.g., 2°C, 50% RH) may take 75 years to experience a similar change. This illustrates the way in which storage conditions can be used to determine the frequency of condition assessment. As a rule, storage at low temperatures makes frequent monitoring less critical. In practice, archivists can estimate how often the collection, or certain portions of it, should be re-checked by using the Wheel (degrading film side) included in the *IPI Storage Guide for Acetate Film*.[7] By selecting the existing storage temperature and relative humidity (RH) they can determine the approximate time it will take for a significant decline in condition to take place (from actively decaying to critical condition). While archivists can determine monitoring frequency based on their own situation, Table II provides some general guidelines. Decaying films stored near or at room should be monitored very closely (rechecked at least every 2 years). Decaying films stored at cold or freezing temperatures need to be rechecked at least every 25 years. Rechecking films at A-D Strip level 3 is of no particular value, because once these decaying materials have reached the measurable limit, no new quantitative information can be gained.

ASSESSMENT OF STORAGE CONDITIONS

Climate assessment is one of the cornerstones of motion-picture preservation. The objective of storage climate assessment is to determine if the existing storage conditions can guarantee that the collection will last as long as required. It consists of evaluating the overall impact of the conditions maintained in the vaults on film stability. It has been consistently demonstrated that heat and humidity are major contributors to the problem of vinegar syndrome. Therefore, temperature and RH are the determining parameters that need to be monitored. Because environmental conditions inside the storage area may change with the weather, the seasons, daily cycles, HVAC performance, and inevitable equipment failures, a year's worth of data including such changes has greater value than a one-month data set or a one-day data set. Although various tools can measure conditions and collect data, electronic data-loggers are preferable to mechanical hygrothermographs because they not only measure temperature and RH over time but also store the data in electronic form for later analysis.

Several collection management tools are available with which archivists can assess the impact of storage conditions on film stability. The Wheel included with the *IPI Storage Guide for Acetate Film*[7] and the *Preservation Calculator*[8] provide easy ways to associate various temperature and RH pairs with acetate base life expectancy. These tools quantify the impact of storage temperature and RH, assuming that these conditions are relatively steady. The *Climate Notebook,* currently under development at IPI, will be able to do more sophisticated analysis that can chart the effects of *changing* conditions on film stability.

As a rule, any collection stored near or at room conditions will decay at an unacceptable rate. Room-condition storage obviates further climate assessment; improved storage is certainly needed if the collection is to survive for more than a few years. In less extreme situations, the institution's goals for collection life expectancy may or may not be met. If not, storage improvements are called for. These can be approached in two consecutive steps: first, optimizing the existing storage, and then, if required, planning a new special storage facility.

Optimize existing storage

Climate assessment should be accompanied by a performance check on the climate-control equipment done by archivists together with engineering and maintenance staff. Experience shows that, in most instances, there is room for improvement and money saving through optimization of existing equipment. The bottom line is that archivists need to know how good the storage area is in terms of preserving their film collections and how cost-effective their climate-control system is. Testing the capability of the existing equipment by moving toward lower temperatures is recommended. Even small set point changes can significantly improve film stability. Archivists can estimate the effect of any of these improvements by using any of the management tools mentioned above. If the improvements are not satisfactory, it is possible to reverse the approach and determine what temperature and RH levels are needed to achieve the life expectancy requirements. Standards recommendations[1,2] are good targets to use when planning a new storage facility. However, any number of temperature-RH pairs can provide proper storage. Archivists can see this for themselves by using the *Storage Guide* Wheel or the *Preservation Calculator*.

Decide between macroenvironmental and microenvironmental alternatives

Archivists have the choice of either controlling the macroclimate in the storage area or creating microclimates in sealed enclosures. Both alternatives can benefit film stability. Before deciding, archivists need to consider the following facts: (1) the benefits of macroenvironment control far exceed those of microenvironments, especially if cold storage temperatures are used, and (2) the use of sealed microenvironments has practical implications, such as increased handling.

Maintaining proper conditions throughout the whole storage area benefits the entire collection and can improve film stability by a factor of 100 if low temperatures are used. By comparison, near or at room temperature, moisture-controlled microenvironments created by adding 5 w% molecular sieves (twice the recommended amount)[6] to sealed cans can provide a factor of stability improvement of three to four. A similar improvement can be achieved by lowering macro RH from 50% to 20%. Storing sealed microenvironments in cold temperatures greatly increases the factor of improvement to film stability. Thus, the microenvironmental option has value, particularly if high RH in the storage area cannot be reduced by dehumidification equipment.

With macroclimate control, film handling is minimized. Once film materials are placed in proper storage, they are likely to be handled only for access or condition monitoring (see Table II). Film cans need not be sealed; in fact, open (vented or unsealed) enclosures are recommended. Using microenvironments increases handling, because films must be placed in plastic bags and taped cans. The recommendation that molecular sieves be replaced periodically[6] means additional handling (every two years at room conditions and every ten to fifteen years in cold temperatures). Because molecular sieves benefit film stability mostly by adsorbing moisture from the film, it is suggested that film accessed and used at higher RHs should be returned to storage with fresh molecular sieves. Based on these considerations, macroclimate control is the most practical option for large collections. Microenvironments are more practical for small collections or portions of large collections, but are not necessarily the best and only choice. Decision criteria are presented in Table II.

Plan cold storage

Storage at low temperatures is the only way to *maximize* the stability of photographic film. If the improvements achieved by optimizing the existing storage are insufficient, planning a special storage area is the next step. Planners will have to choose equipment that can accommodate the volume of the collection and meet the climate requirements for optimum storage. The process of cold storage planning has been described in the *Storage Guide for Color Photographic Materials*.[9] The approach describes two methods: one in which temperature and RH are controlled, and one in which only temperature is controlled and film materials are packed in moisture-proof bags. It is possible with these two options to adapt the equipment to the volume of the collection. A small number of films can be stored inside a small walk-in chamber or freezer. If the equipment does not have humidity control, the films must be wrapped in moisture-proof packaging. Simple packaging methods have been described in earlier publications.[10] A larger collection naturally requires a larger cold space. In this case, controlling both temperature and RH is more efficient than packaging film individually. Using cold storage requires a special handling policy for occasions when film is taken out of storage. The goal is to prevent moisture condensation when the film is moved into a warmer environment. This problem can be addressed by either planning a temperature- and humidity-controlled staging room or by placing the films in moisture-proof bags before removing them from cold storage. Minimum warm-up times have been determined for a variety of configurations.[11] An equilibration period of a half-day to one day is a conservative assumption in most real-life situations and is given in Table III as a guideline.

Use the right enclosure

Studies have demonstrated that enclosure design can increase the rate of base decay. Data show that, at room temperature, sealed enclosures accelerate acetate degradation, a persuasive argument for using open (vented or unsealed) enclosures. Data also show that open enclosures do not reduce acid content in degrading film to acceptable levels. In fact, further degradation has been observed in open enclosures during natural aging studies.[12] Enclosures are considered to be only a *secondary* factor in controlling vinegar syndrome. Using proper storage conditions outweighs any possible benefit from enclosures and mitigates any potential detrimental effects that enclosures may have. Archivists can choose among plastic vented cans, corrosion-resistant metal cans, and cardboard boxes, all of which are appropriate for film storage. Enclosure condition is an important issue, however; containers in poor condition do not provide physical protection to the film, and rusted metal cans can promote base decay and are a source of dust.

DEALING WITH CHEMICALLY DAMAGED FILM

The advanced stages of vinegar syndrome make acetate film brittle, increase film shrinkage, and may decompose (soften) the image layer. Film in an advanced state of decay is easily damaged if handled. Excessive shrinkage makes projection difficult and can make duplication by traditional photographic techniques impossible. Softening of the gelatin emulsion, the result of chemical changes in the gelatin binder, makes any aqueous treatment dangerous. (Gelatin decomposition can make the image layer water-soluble).

Although cold storage can stabilize damaged films, it will not restore them. Acetate decay is a one-way street: chemical degradation of film base is an irreversible process. A number of laboratory treatments have been used to deal with the problem. These are reviewed in "Restoration and Preservation of Vinegar Syndrome Decayed Acetate Film"[13] and are beyond the scope of this paper. It should be emphasized, however, that any laboratory treatment involves high risk for already damaged film, and that the consequences of such treatments have not always been fully investigated. Today, the rapid development of new digital technologies increases the possibilities for dealing with damaged films. This perspective emphasizes the need for applied research on film reconstruction. However, no matter how sophisticated future technologies might be, minimizing film damage by controlling vinegar syndrome today is a sound and cost-effective option.

Conclusion

Today, the entertainment industry is fostering the emergence of new technologies that threaten to make film obsolete. Photographic film has formed the very core of cinema, however, and has unquestionable assets, even in the long term. Today, acetate base film represents the largest part of worldwide motion-picture film holdings, and evidence shows that most of the collections are threatened by the vinegar syndrome. Research findings, however, have served as the basis for articulating a preservation strategy of practical value to film archivists. Kept in proper storage, acetate film collections, even those already starting to decay, can last a long time. The key to future access to our film heritage in its original form is the control of chemical decay. To do this in practice, it is urgent that the current state of our film collections be assessed and that the process of improving poor storage situations is put into motion throughout the film archives community. The step-by-step approach described in this paper is an attempt to achieve this objective. The flow-chart entitled *Action Plan for Film Archivists* (see Figure 1) gives an overview and proposes an action plan to guide archivists toward better assessment of the vinegar syndrome problem and the best remedies, based on their own institutional profiles. Surveying and assessing collections as described above represents applied research that should be undertaken in the field. In the years ahead, digital technologies may make possible the affordable recovery of some of the already damaged works. For now, improving film storage conditions will allow archivists to buy time for their collections.

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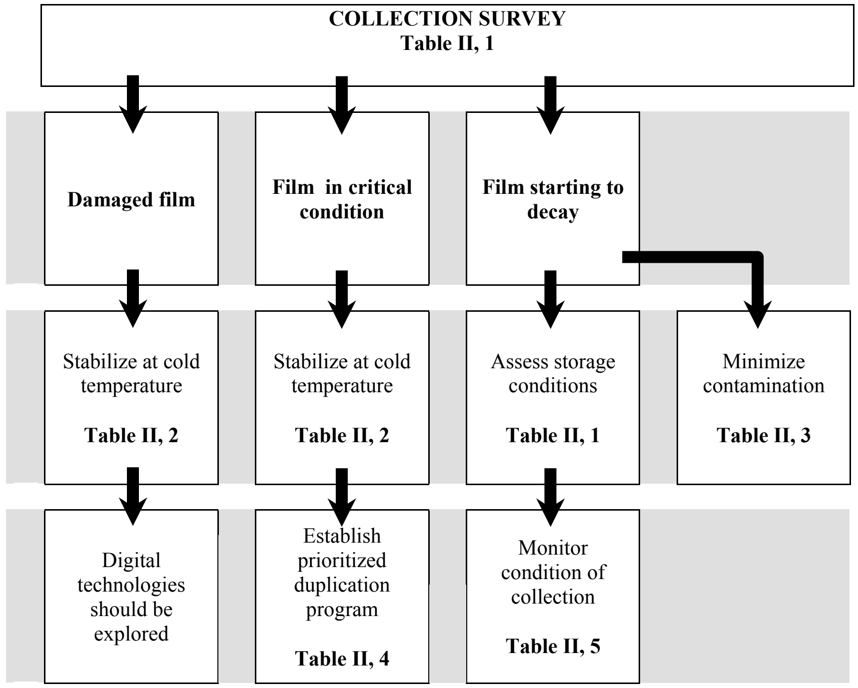

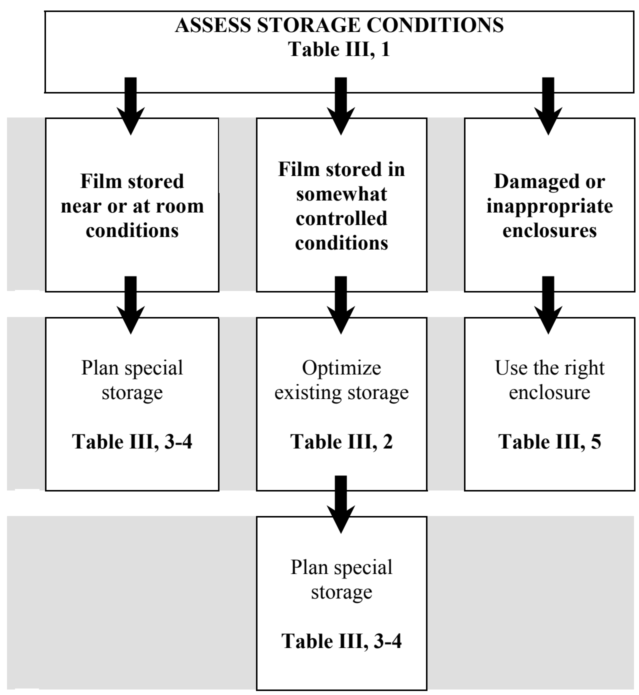

Figure 1. Action Plan for Film Archivists

Table II: Survey of acetate film collections and recommended actions.

	What needs to be done?	Why is it important?	How is it done?	What comes next?
1	**Do a condition survey to evaluate the state of preservation of the film collection**	• *Quantifies* the potential for film loss. • Present condition of the film determines its remaining life span. • Already decaying film may have a very short life span.	• Test film using acid-detector strips. The test is nondestructive and easy to perform. The color of the strip indicates the level of acidity of the film.[3,4] • Test by one of three methods: **Statistical sampling** to identify and evaluate affected areas throughout the collection.[5] **Testing of specific suspect portions of the collection**. **Item-by-item testing** to evaluate the condition of individual film rolls.	• Survey results may suggest that you: **(1) Reassess storage conditions** **(2) Stabilize films in critical state of decay** **(3) Minimize the risk of contamination** **(4) Prioritize films for duplication.** • Guidelines for using A-D Strips (if reading is above level 0, collection is affected by vinegar syndrome): **Level 0**: cool and cold storage improves stability. **Above level 0 to level 1.5**: cool and cold storage will postpone further decay. Film condition should be monitored. **Level 2 and level 3**: films must be stabilized in cold storage, and duplication should be planned.
2	**Stabilize films in advanced state of decay**	• Actively decaying films may have a short life span. • They may not last long enough under current storage conditions to be duplicated	• Guidelines for using A-D Strips: Film at level 2 and level 3 must be stabilized. • Storage in cold or subfreezing temperature postpones further chemical decay.	• Establish a duplication program
3	**Minimize the risk of contamination**	• Vinegar syndrome is infectious. • Degradation byproducts released by decaying films promote further acetate base decay.	• Use cold storage temperatures to mitigate harmful effect of degradation byproducts on film stability. • Minimize the amount of degradation byproducts in the storage area. • For large collections, promote air exchange and use air purification system. • For small collections it may be practical to use sealed microenvironments with adsorbents (e.g., molecular sieves)[6] to address the problem item-by-item.	• Monitor air quality in the storage area. • This approach does not replace the need for cold storage temperatures.
4	**Prioritize films for duplication**	• Acetate base decay progresses at an ever-faster rate. • Film in advanced state of chemical decay may have a very short life span depending on storage conditions.	• Use survey results to prioritize individual films or portions of the collection for duplication. • Guidelines for using A-D Strips: Level 2 and level 3 characterize film in advanced state of decay, and pinpoint film with higher risk.	• Decaying films must be stabilized in cold storage while waiting for duplication. • Duplication is expensive. The fact that these duplicates must be preserved makes an environment-based preservation strategy even more valuable and cost-effective.
5	**Monitor the condition of film collection**	• The condition of the collection will change over time. • Acetate base decay progresses at an ever-faster rate. • Periodically reassessing the condition of the collection helps to control vinegar syndrome.	• Test film using acid-detector strips. • Base monitoring frequency on film condition and existing climate conditions. • Use the Wheel (side for degrading film) included in *IPI Storage Guide for Acetate Film*[7] to determine approximate time it will take for acidity to increase from 0.5 to 1 (from A-D Strip level 1.5 to 2). • To make monitoring less critical, store film in cold or freezing temperatures.	• Recheck the collection using the following guidelines: **Film stored near or at room conditions:** Recheck every 2 years or less. **Film stored at cool temperatures:** Recheck at least every 5 years. **Film stored at cold or freezing temperatures:** Recheck at least every 25 years.

Table III: Assessment of storage conditions and recommendations.

	What needs to be done?	Why is it important?	How is it done?	What comes next?
1	**Assess climate conditions**	• Temperature and RH govern the rate of chemical decay. • As a rule, any film kept at or near room conditions decays at an unacceptable rate. • Low temperature and low RH improve the stability of film base and dyes. • Knowing the climate conditions makes it possible to predict the longevity of both fresh and decaying acetate base film.	• Measure and record temperature and RH levels in the storage area. • Monitor continuously with electronic data-loggers. • Quantify the effect of current storage conditions on film life expectancy using one of the following options: (1) Wheel included in *IPI Storage Guide for Acetate film*, (2) IPI's *Preservation Calculator*,[8] and (3) IPI's *Climate Notebook.* • Estimate the remaining life span of already decaying films stored under current conditions using the Wheel (side for degrading film) included in the *IPI Storage Guide for Acetate Film.*[1]	• Life expectancy estimates may or may not meet the institution's requirements. The latter situation calls for storage improvements. • Improve storage climate by: **Optimizing the existing storage** AND/OR **Planning for a special storage area**.
2	**Optimize existing storage**	• Optimizing existing equipment will often save energy and may improve the longevity of film materials at the same time. • Even small set point changes can benefit film stability.	• Analyze both storage conditions and the performance of the existing equipment. • Determine the capability limits of existing climate control equipment. • Move toward *lower* storage temperatures and moderate RH. • Engineers and archivists should work together to make the best of the environmental control system.	• Optimization of existing storage may be only a short-term option. • Re-assess the impact of the new conditions on film stability. • If film life expectancy still does not meet requirements, determine climate conditions needed using one of the management tools mentioned below. • Determine life expectancy by: Picking various temperature and RH pairs and using the Wheel (*IPI Storage Guide for Acetate Film*) or the *Preservation Calculator* OR Simulate climate improvements using the *Climate Notebook*. • In the end, a new special storage facility may be needed. • As a rule, cold storage is the best option for preserving photographic film.

	What needs to be done?	Why is it important?	How is it done?	What comes next?
3	**Decide between macroenvironmental and microenvironmental alternatives**	• Archivists have the option of controlling temperature and RH in the whole area or using moisture-controlled microenvironments. • Both approaches can improve film stability. • Their benefits vary in magnitude and their implementation has practical significance for archivists. • Moisture-controlled environments are valuable if all other possibilities of reducing high RH in the macroenvironment have been ruled out.	**Macroenvironment** • For the greatest potential improvement, use macroclimate control and cold temperatures. • For large collections, it is the most practical option. • Install refrigeration and dehumidification systems.	• Maintain equipment. • Monitor climate conditions.
			Sealed microenvironments • For small collections or portions of large collections, microenvironments may be practical but not necessarily the best and only choice. • The benefits of microenvironments on film stability are similar to those obtained at low macroenvironmental RH. (At constant temperature, 5 w % molecular sieves in sealed cans can improve film stability by a factor of 3 to 4. The same improvement can be achieved by keeping RH at 20%.) • Use sealed enclosures to implement the microenvironmental approach. • Use adsorbents (e.g., molecular sieves) to control the moisture in the microenvironment and adsorb some of the degradation byproducts.	• Adsorbents should be replaced periodically. Follow product recommendations. They may also be replaced whenever film is accessed. • Estimate the benefits of lowering storage temperature by using either the Wheel included in the *IPI Storage Guide for Acetate Film* or the *Preservation Calculator*. Pick various temperatures at 20% RH and determine the predicted life expectancies. (Microenvironments with 5 w% molecular sieves have benefits similar to those of 20% RH.) • Place microenvironments in cold temperatures to enhance their benefits.
4	**Plan cold storage**	• Cold temperature and low RH have the greatest potential to improve stability of both old and new films. • Using cold or subfreezing temperatures can stabilize film in an advanced state of decay. • Cold storage is cost-effective compared to duplication.	• Choose the type of equipment that is appropriate for the size of the collection (cold vaults, walkin chambers, and freezers). • Choose one of the following methods: **Both temperature and RH are controlled.** This is the most practical approach for large collections. **Only temperature is controlled.** Films must be packed in moisture-proof enclosures. This can be practical for small collections or portions of large collections. This method requires more handling. Inexpensive freezers can be used.	• Establish film access policy to avoid the risk of condensation when films are taken out of cold storage. • Choose one of the following methods: **Use a temperature- and RH controlled-staging room during warm-up.** **Place films in moisture-proof bags before removing from cold storage, and allow time for warm-up.** • Minimum warm-up time depends on the temperature changes that the film experiences and also is a function of the mass of film. A half-day to one-day equilibration period is a conservative assumption in most instances.
5	**Use the right enclosure**	• Enclosure design, materials, and condition can effect film stability for better or worse. • At room temperature, sealed and tight enclosures have a marked detrimental effect.	• In temperature- and RH-controlled storage, use open enclosures such as vented plastic cans and unsealed metal cans. • Replace rusted metal cans, which can promote acetate base decay. • Replace all enclosures in poor condition.	• Because enclosures are a *secondary* factor in controlling vinegar syndrome, the storage conditions should be assessed. No existing enclosure can outweigh the detrimental effects of poor storage conditions. However, the detrimental effects of sealed or tight enclosures are eliminated by cold storage.