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Preservation Metrics

Recognizing the need for a way to transform collected environmental data into easily accessible information that could be used to manage the storage environment for long-term preservation, IPI developed Preservation Metrics. Each metric evaluates the quality of environments into a single value representing the degree of risk for a particular form of material decay, taking into account all the ups and downs of the environment during the monitoring period. The metrics identify the risk of environmentally-induced chemical change in organic materials, dimensional change or mechanical damage, biological decay or mold risk potential, and moisture-induced corrosion. To use the metrics effectively, you simply need to understand what forms of decay they address and what the numeric values tell you about the preservation quality of the space. IPI's Preservation Metrics® allow you to accurately and objectively determine how well each storage area is performing for collection preservation, how well one environment is performing compared to another, and how various collection materials are faring in a particular location. Metrics can flag potential problems and document the impact of changes or adjustments made to improve conditions. Analysis based on metrics can be used to argue for funding or other resources needed to make improvements in storage conditions.

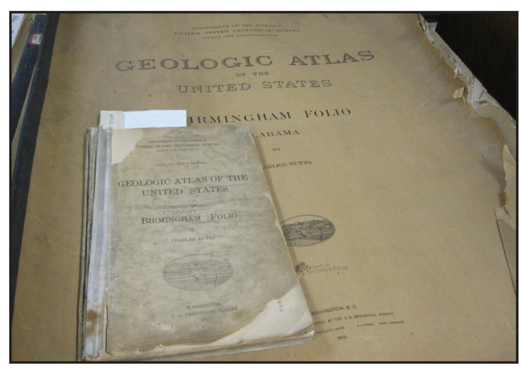
Chemical Change/Natural Aging

Metric Used: Time Weighted Preservation Index (TWPI)

Role of Environment: Chemical change in organic materials arises in response to heat energy (temperature) and available moisture (relative humidity). Temperature and RH combine to control the rate of chemical reactions. Temperature matters more than RH in the sense that great benefit can result from very cool temperatures and great harm can result from very warm temperatures. The rate of deterioration accelerates as temperature and relative humidity levels increase.

Measures: The rate of spontaneous chemical change in organic materials. The TWPI algorithm integrates the T and RH values as they change over time into a single estimate of the cumulative effects of the environment on the rate of chemical decay.

TWPI > 75	**GOOD – slow rate of chemical decay**
TWPI 45 – 75	**OK – generally OK but fast decaying organic materials will be at elevated risk**
TWPI < 45	**RISK – accelerated rate of chemical decay in organic materials**



What's at Risk: All organic materials (paper, textiles, wood, vellum, plastics, dyes, leather, fur, etc.). Chemical decay is particularly significant for book and document collections. Fast decaying organic materials include acidic paper, color photographs, and cellulosic plastics. Examples of chemical decay include embrittlement of paper, breakdown of textile fibers, fading and deterioration of pigments.

Reduce Chemical Decay Risk: Chemical change is a slow process—what matters most are the long-term average temperature and RH. Make it as cool as possible while maintaining RH below 55%, keep summer dew point temperatures as low as possible.

Mechanical Damage/Dimensional Change

Metrics Used: Minimum & Maximum % Equilibrium Moisture Content (Min EMC & Max EMC) and % Dimensional Change (% DC)

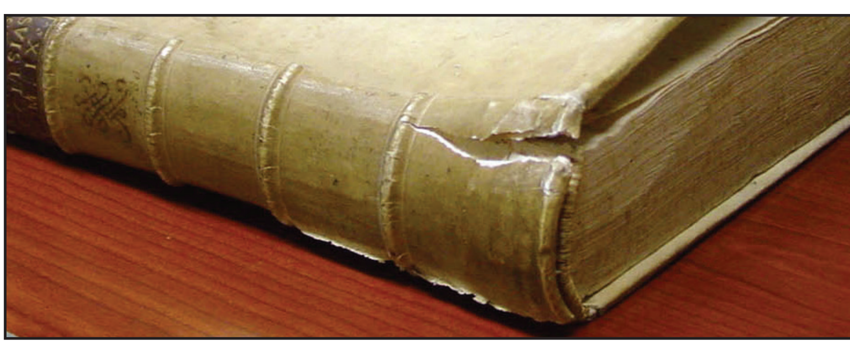
Role of Environment: Mechanical or structural damage is a form of decay that effects hygroscopic organic materials (those that absorb moisture). Environmentally-induced mechanical damage is primarily driven by extremes of RH, although temperature extremes can affect the degree of risk. Hygroscopic materials respond to the amount of RH in the environment by expanding and contracting as they absorb and release moisture. At low RH, objects shrink and become brittle. At high RH, they swell and soften. This puts physical stress on objects and can lead to damage in vulnerable collections.

Measures: The amount of moisture in the environment and the degree of fluctuation between periods of dampness and of dryness, all of which promote mechanical or physical damage in vulnerable materials.

Min EMC ≥ 5% AND Max EMC ≤ 12.5% AND %DC ≤ 0.5%	GOOD – minimal risk of mechanical damage; not too dry or too damp, and almost no fluctuation between the two extremes
Min EMC ≥ 5% AND Max EMC ≤ 12.5% AND 0.5% < % DC ≤ 1.5%	OK – not too dry or too damp and minimal fluctuation between the two, however sensitive material may be at higher risk
Min EMC < 5% OR Max EMC > 12.5% OR %DC > 1.5%	RISK – heightened risk of mechanical damage; either too dry, too damp, or too much fluctuation between the two

What's at Risk: All organic materials (paper, textiles, wood, vellum, plastics, dyes, leather, fur, etc.). The risk of mechanical damage is particularly significant for composite objects due to various materials shrinking and swelling at different rates. This includes fine and decorative art collections, rare books, paintings, furniture, textiles, etc. Examples of damage due to high RH include curling paper, softening emulsions, warped wood, and differential expansion. Examples of damage due to low RH include brittleness, tearing, cracking of emulsions, etc. Risk also results from wide and frequent changes in RH.

Reduce Mechanical Damage Risk: Keep excursions below 30% RH or above 55% RH short and infrequent. Avoid low winter dew point temperatures and high summer dew point temperatures.



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Biological Decay/Mold Risk

Metric Used: Mold Risk Factor (MRF)

Role of Environment: Biological decay is caused by living organisms, most notably mold and mildew (fungi) and insects. Although temperature does help determine the likelihood and severity of biological attack, the major factor is RH. Both molds and insects thrive at moderate temperatures and elevated RH. Mold spores require a sustained high relative humidity level for a certain period of time in order to propagate.

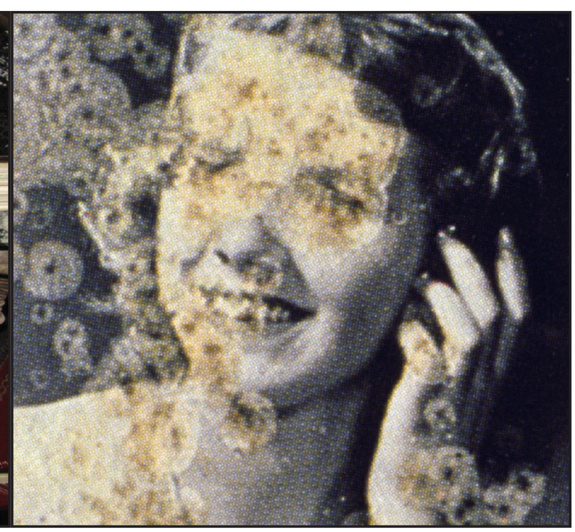
Measures: The risk of mold germination and the potential for mold growth based on collected temperature and RH data over time. Data is analyzed to determine if environmental conditions promote biological decay, including the growth of xerophilic mold and mildew and the risk of insect infestation. The MRF algorithm integrates T and RH over time, creating a running sum of progress toward mold germination.

MRF ≤ 0.5	**GOOD – little or no risk of mold growth**
MRF > 0.5	**RISK – An MRF greater than 0.5 indicates that mold spores are half way to germination. An MRF greater than 1.0 indicates that mold spores have germinated, entering a vegetative mold state and visible mold could be actively growing.**

NOTE: There is no OK rating for mold growth – either there is the potential for mold germination (RISK) or there isn't (GOOD).

What's at Risk: Active mold produces enzymes that can digest organic materials, weakening or destroying the object. All organic materials (paper, textiles, wood, vellum, plastics, dyes, leather, fur, etc.) and inorganic materials with organic films are vulnerable. Evidence includes increased insect activity, staining from mold bloom and obvious mildew and mold growth.

Reduce Mold Risk: Minimize excursions above 55% RH to reduce the risk of mold growth. Insect infestations are minimized by keeping RH below 50% and temperatures cool. Keep summertime dew point temperatures as low as possible.



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Metal Corrosion

Maximum % Equilibrium Moisture Content (Max EMC)

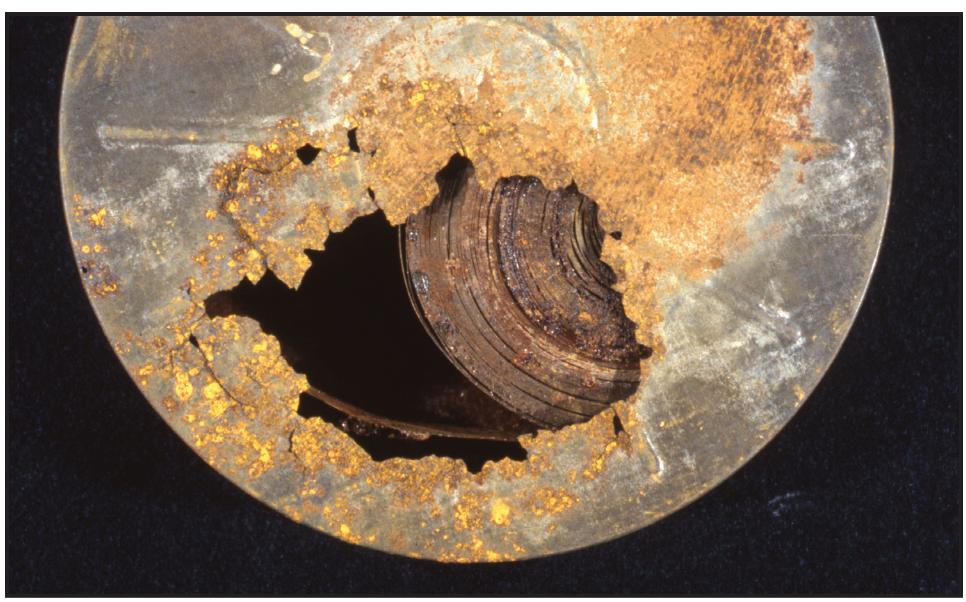
Role of Environment: Metal corrosion is a form of chemical change driven primarily by moisture. Corrosion begins when RH levels are 55% or greater. High temperatures and the presence of pollution, dust, salts, oils, or active corrosion can allow corrosion to occur at lower humidity levels.

Measures: The risk of environmentally-induced corrosion of metals (mainly ferrous metals) is based on the Max EMC metric. This is because the Max EMC value is calculated using a 30-day moving average of RH rather than the instantaneous RH. This helps avoid false positive results based on a very brief period of high RH, since this scenario is not likely to cause corrosion. The metric for metal corrosion incorporates two levels of severity based on adjusted RH. Because metal corrosion is dependent on available moisture, the Max EMC indicates whether or not metallic objects would corrode based on the amount of moisture in the environment.

Max EMC ≤ 7.0	**GOOD – minimal risk of corrosion due to excessive dampness**
7.1 ≤ Max EMC ≤ 10.5	**OK – limited risk of corrosion due to excessive dampness, however sensitive material may be at a higher risk**
Max EMC > 10.5	**RISK – accelerated risk of corrosion due to extended periods of dampness**

What's at Risk: Metal objects or objects with metal components, including some black & white photographs, textiles, and inks. Archaeological or salt-encrusted metals are particularly sensitive. Examples of damage include silver tarnish, bronze disease, copper corrosion or verdigris, and rusted iron.

Reduce Corrosion Risk: Keep RH levels below 55%. Minimize excursions above 55%.



The Image Permanence Institute, part of RIT's College of Imaging Arts and Sciences, is a university-based, non-profit research laboratory devoted to scientific research in the preservation of visual and other forms of recorded information.

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