Supplement 2- Temperature, Relative Humidity and Air Pollutant Tables

Table 1: Temperature and Relative Humidity Standards

Overall Temperature and Relative Humidity Guidelines
This guidance reflects research evidence of the effects of temperature and relative humidity on collection materials that supports moving away from set points towards bands. It also reflects research showing that different materials have different requirements, and past storage conditions a material was exposed to can affect its storage requirements for the future. The guidelines for temperature and relative humidity conditions balance long-term preservation of the holdings and energy efficiency.

The rates of chemical, biological, and physical deterioration increase as temperature and relative humidity increase; therefore, keeping holdings in a low temperature and moderate relative humidity environment is the most efficient and cost-effective way of prolonging the life of the holdings.

Very low temperatures are effective in slowing chemical degradation and should be maintained for highly sensitive materials. Acidic papers, magnetic media, and many films and plastics have a usable life of only decades if stored at temperatures at or above 70ºF.

Standard Storage: Low Sensitivity Holdings
Holdings not readily affected chemically and mechanically by higher temperatures, relative humidity, and pollution. Most papers, paper-based black-and-white photographs, polyester-based black-and-white film, ceramics, glass, and metals are examples of low-sensitivity holdings. It also includes holdings where cold storage does not increase the longevity of the holding, such as electronic and magnetic media, and may cause damage.

Cold Storage: High Sensitivity
Holdings highly affected by temperature and relative humidity and pollution. These include cellulose acetate photographic media, and color films, and color prints of high significance.

Specific microclimates (cases, sealed frames, special housings) may be required for some materials on exhibit and in storage. Materials might include parchment, some photographic holdings, ivory, organic composite artifacts, fragile bound volumes, and unstable metals. Items loaned from other institutions may require tighter relative humidity control depending on the loan agreements.

Location	Material Sensitivity: Types of holdings or media	Storage Temperature	Relative Humidity Range
Textual Holdings Storage (and Mixed Storage*)	***Low Sensitivity***		
Stacks, bays, or rooms where textual records are housed for long-term storage.	**Paper:** Textual records including bound volumes.	50-65º F	30 - 50%
Non-textual Holdings Storage	***Low Sensitivity***		
Stacks, bays, or rooms where non-textual records such as audiovisual media, microfilm, photo albums, and cartographic materials are housed for long-term storage.	Photographic: **black-and-white paper prints, polyester-based film material, glass plate negatives.** Color Prints***: Cibachrome, Polaroid, and chromogenic** * To slow the rate of change it is recommended that color prints identified as significant should be kept in cold storage.	50-65º F	30 - 50%
	Paper: maps, plans, punch cards		
	Electronic Media: computer tapes and disks, optical disks, hard drives (These materials are included in low sensitivity, because cold storage does not increase their longevity and can cause damage to this type of holdings.)		
	Audio / Visual Media: video tapes, audio tapes, disk recordings, wire recordings (These materials are included in low sensitivity, because cold storage does not increase their longevity and can cause damage to this type of holdings.)		
Artifact Holdings Storage	***Low Sensitivity***		

Stacks, bays, or rooms where two- and three-dimensional artifacts are housed for long-term storage. Typically located in Presidential Libraries.	Ceramics, glass, stable metals, tanned leather, textiles, stable oil and acrylic paintings, furniture, watercolors, most modern books	50-65º F	30 - 50%
	Medium Sensitivity		
	Untanned skin products, organic composite objects, flaking surfaces	50-65º F	40-50%
	High Sensitivity		
	Parchment, ivory, lacquerware, unstable glass, unstable efflorescent ceramics, unstable iron and bronze, some plastics	Generally, 50-65º F. Some plastics may benefit from cold storage.	Specific microclimates created through use of conditioned silica gel in storage cabinets, cases, sealed frames, or special housings may be required for some high sensitivity artifacts
Cold Storage	***High Sensitivity***		
Stacks, bays, or rooms used to store sensitive media known to deteriorate rapidly at higher temperatures. Lower temperatures prevent deterioration of media in good condition and slow down	**Cellulose acetate-based media:** motion picture and still picture film negatives, aerial film, x-rays, microfilms and microforms, vesicular microforms, slides, animation cells **Color:** still picture negatives and transparencies, and	35º F Do not allow temperature to go below	30-40%

existing autocatalytic decay.	motion picture film **Plastics:** dependent on type of plastic and significance. Microclimates may also be considered. **Nitrate film:** has many storage requirements beyond temperature and humidity. Please contact RX if identified. To slow the rate of change it is recommended that color prints identified as significant should be kept in cold storage.	32º F. This will prevent the accumulation of damaging moisture from micro-condensation that can occur during freeze – thaw cycles.	
Cold Storage Transition / Acclimation Room	***High Sensitivity***		
Room used to slowly acclimate holdings stored in cold storage to higher temperatures before they are moved to processing or other rooms for use. Holdings remain in Acclimation Room 4 -24 hours to prevent micro-condensation, according to RX guidance.		Dependent on dew point calculations. (consult with RX) For 35° F Cold Storage, Acclimation Room should be 50° F	30-50%
Frozen Storage	***High Sensitivity***		
Stacks, bays, rooms, and stand-alone freezers used to store sensitive media known to deteriorate rapidly at higher temperatures. Alternative to cold storage, especially for highly sensitive, highly	Priority is given to deteriorated motion picture film.	<30º F Do not allow temperature to go above	30-40%

significant, or deteriorated holdings.		32º F. This will prevent accumulation of damaging moisture from micro-condensation during freeze – thaw cycles.	
Frozen Storage Transition / Acclimation Room	***High Sensitivity***		
Room used to slowly acclimate holdings stored in frozen storage to higher temperatures before they are moved to processing or other rooms for use. Holdings remain in Acclimation Room for a period of time dependent on temperatures and material vulnerability to micro-condensation.		Dependent on dew point calculations.	30-40%
Mixed Media Storage Rooms	***Mixed Sensitivity***		
Stacks, bays, or rooms used to store records that are predominately paper-based but which may have non-textual or artifact holdings interspersed.		50-65° F	30-50%
Holdings Work Rooms	***Mixed Sensitivity***		
Rooms in which original records are processed, researched, digitized, conserved, or otherwise used. Includes designated processing, preservation, digitization, and research rooms.		50-75° F	30-55%

Exhibit Galleries or Areas	***Low and Medium Sensitivity***		
Rooms or spaces where holdings are displayed, typically in exhibition cases or frames, which meet preservation and security requirements outlined in NARA 1563.		50-75° F	30-55%
Exhibit Cases Displaying Original Holdings	***High Sensitivity***		
Display cases or frames used to exhibit original holdings.		Specific microclimates created through use of conditioned silica gel cases, sealed frames, or housings may be required for some materials on exhibit. Items loaned from other institutions may require tighter RH control, depending on loan agreements.	

Table 2: Air Pollutant Thresholds for NARA Holdings Storage Rooms

This table lists the gaseous air pollutants that are the primary risks to NARA's paper-based, photographic, and audio-visual holdings. For these materials, experimental studies indicate that the listed pollutants can cause significant damage at low micrograms per cubic meter (µg/m3) concentrations over periods of a few years or decades. This risk to the bulk of holdings can be cost-effectively reduced at the room level by air filtration. Certain artifacts or groups of special materials may be more sensitive or affected by pollutants not listed. While room-level air filtration may assist in protecting these specific holdings, the use of microclimates and other protective measures is a more effective approach.

Outdoor Generated Pollutants	**Common Sources**	**Maximum Concentration After Air Filtration** **µg/m^3:** micrograms per cubic meter **ppb:** parts per billion	
Sulfur dioxide (SO2)	Coal combustion, industrial processes	5 µg/m^3	1.9 ppb
Nitrogen dioxide (NO2)	Engine exhaust, power plants, industrial processes	5 µg/m^3	2.6 ppb
Ozone	By-product of engine exhaust	5 µg/m^3	2.5 ppb
Indoor Generated Pollutants			
Acetic acid	Cellulose acetate-based materials Paper Certain woods and wood-based products Cleaning products Adhesives during cure	250 µg/m^3	100 ppb

Note: Degrading cellulose acetate film releases high levels of acetic acid. Nearby un-degraded film may absorb this vapor and catalyze new deterioration. In principle, air filtration to low µg/m^3 acetic acid levels could reduce this risk, but this approach does not address the already-degrading film. Cold storage is a much more effective and cost-efficient preservation method for holdings at risk from acetate film degradation sometimes called "vinegar syndrome." The 250 µg/m^3 (100 ppb) concentration indicates the presence of severely deteriorating film.
Note: While ozone is listed as an outdoor pollutant, it may also be generated by some photocopiers and printers.
Note: Pollutant limits for exhibit cases and other types of microclimates are more restrictive. Upper limits are: sulfur dioxide 2.7 µg/m3 (1 ppb); formaldehyde 5.0 µg/m3 (4.0 ppb); acetic acid 10.0 µg/m3 (4.0 ppb)