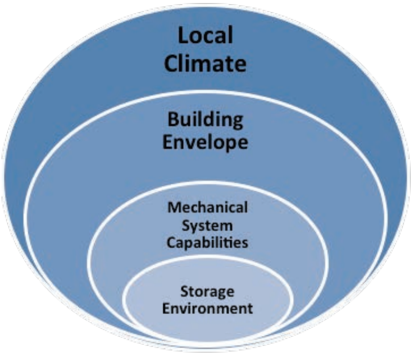
CHAPTER 2:
The Factors that Shape the Storage Environment

The storage environment is shaped by a series of interrelated circumstances. This nested relationship begins with the local climate, particularly the seasonal moisture and temperature profile. The next level of influence includes the building envelope, which provides the first level of protection between the climate and the collection. The passive or mechanical system designed to deal with the extremes and variations of the local climate comprises the third level. Other factors come into play as well, including the needs of the collection, the activities that take place in the space, and the operating patterns of the mechanical system.

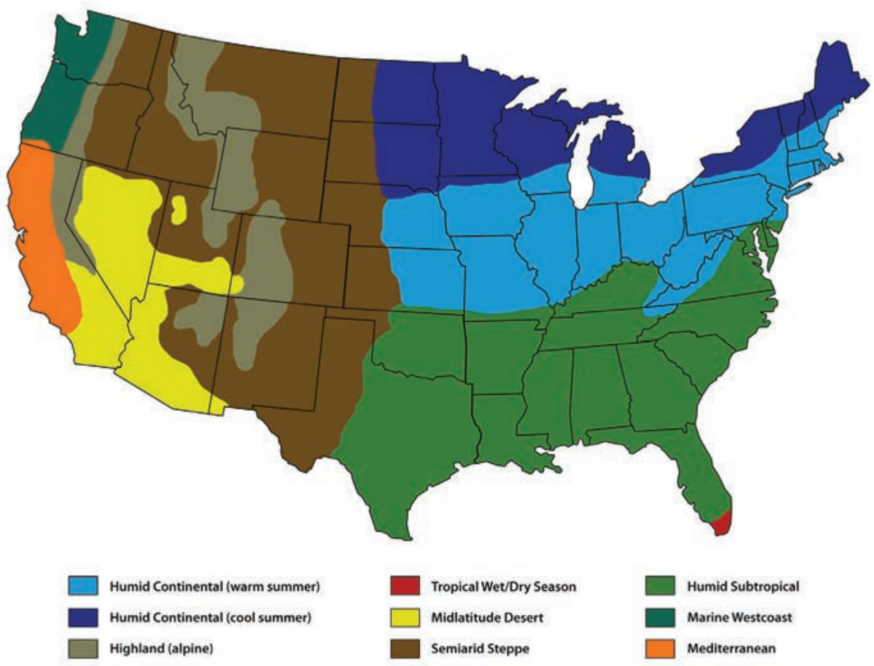


2A The Local Climate

The local outdoor climate is very important because it has a significant influence on what happens indoors. All the air inside the building came from the outside initially. The building's mechanical system, no matter how simple or how complex, was designed to deal with the outside air, particularly the extremes of heat and moisture. The climate situation that mechanical systems are designed to manage will vary depending on the regional climate patterns.

Climate Zones in the Continental United States

The United States can be divided into specific climate zones which vary in temperature, humidity, and dew point based on geographical differences such as elevation, latitude, and average rainfall.



Preservation Challenges in Various Climates

Regional climatic differences influence the environmental management requirements for collections preservation. The descriptions below provide an overview of the challenges presented by various climates in the United States:

Continental Climate

WARM TO COOL SUMMERS AND COLD WINTERS

Mechanical systems should be designed to protect collections in storage from extremes in temperature and relative humidity year round. This requires the use of cooling and dehumidification in the summer to reduce temperature and humidity levels and the use of heat and humidification in the winter to increase temperatures and add moisture.

Dry (Desert and Semiarid Steppe) Climate

VERY DRY, COLD AT NIGHT AND HOT DURING THE DAY, LITTLE RAIN

Mechanical systems should be designed to manage wide fluctuations in temperature. Good air filtration is required to protect collections from dust and soot. Collections should be protected from high levels of sunlight, which can increase the rate of deterioration in vulnerable materials. High humidity is rare. The system should add moisture during periods of low RH to avoid damage to collections from dryness.

Subtropical Climate

WARM AND HUMID SUMMERS WITH MILD WINTERS

The sub-tropical climate is conducive to mold and mildew growth and biological decay. Exterior walls may be susceptible to condensation problems when warm humid air meets cold surfaces. Both adequate moisture barriers and good air circulation are important to protect collections from accelerated decay. Mechanical systems need the ability to increase temperatures and to dehumidify to reduce high RH levels

Tropical, Warm and Humid Climate

HEAVY RAINFALL, HIGH HUMIDITY AND HIGH TEMPERATURES

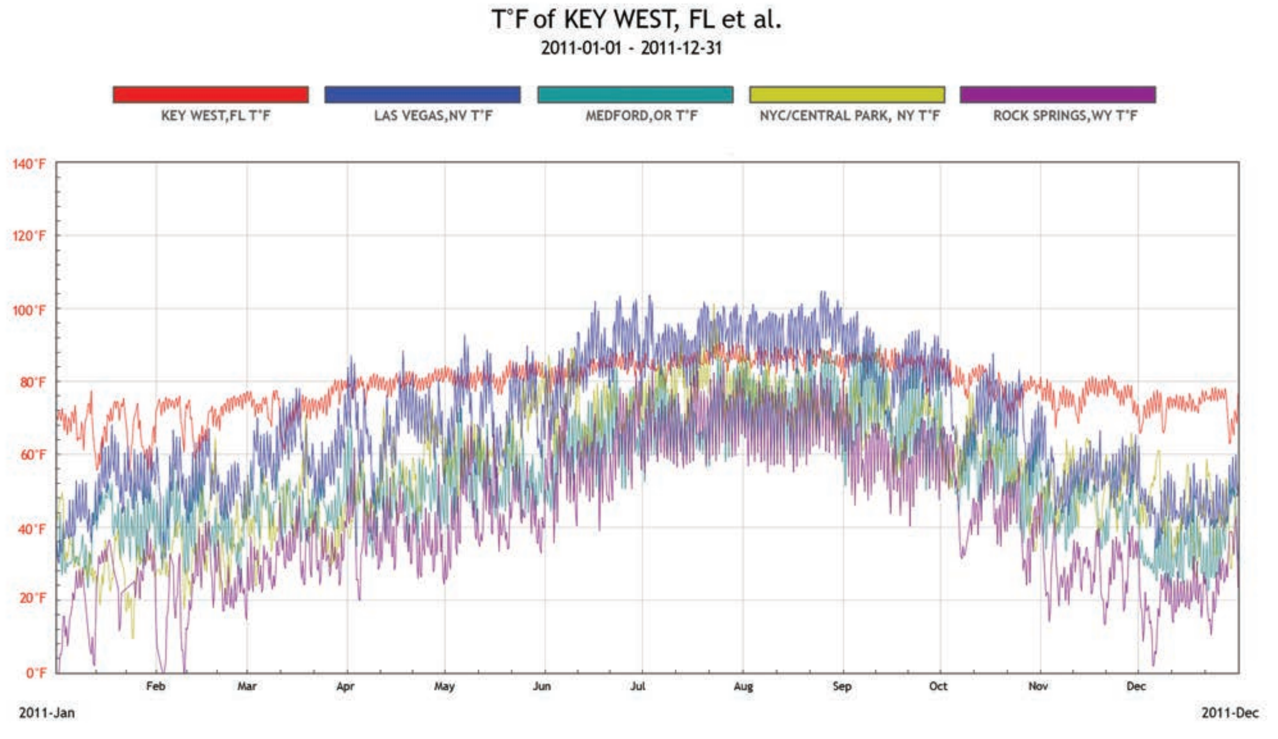
The tropical climate is conducive to biological decay and insect growth. High RH increases the rate of deterioration due to moisture absorption—all organic materials are at risk. Moisture barriers, good air circulation, and the ability to dehumidify are very important.

Historically, regional climate influences the development of regional architectural styles. Thick adobe walls offer shelter from the sun and keep interiors cooler in hot, dry climates. Verandas, courtyards, porches and high ceilings provide protection from the sun, particularly in the south. Homes in tropical areas feature elevated floors, louvered grilles and shutters, and balconies to promote air circulation.

Regional Outdoor Data

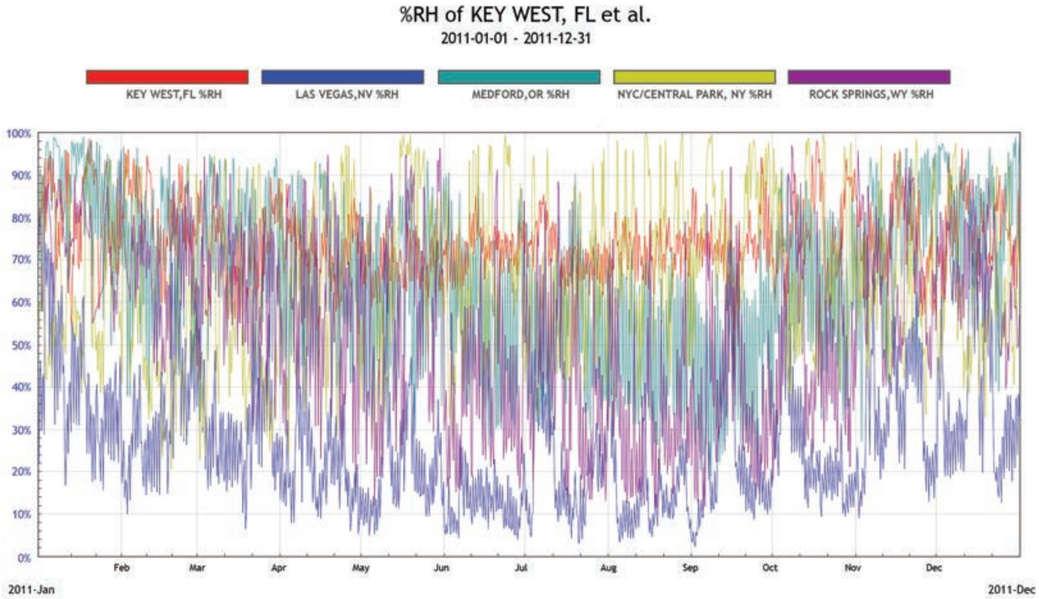
Outdoor data typically shows moderate daily fluctuations in temperature and quite significant daily fluctuations in relative humidity. Seasonal trends are actually more important—most places have a cold winter season and a warm summer, but this can vary by region.

The following graph shows a full year of temperature data from five regions in the United States—Las Vegas NV in the Southwest, Key West FL in the Southeast, New York NY in the Mid-Atlantic, Medford OR in the Northwest and Rock Springs WY, which is on the west end of the Midwest. The key above the graph identifies the colors that correspond to each city. Although temperatures rise in the summer in all regions, the difference between the cold winter temperatures and the hot summer temperatures is more significant in some areas than in others.

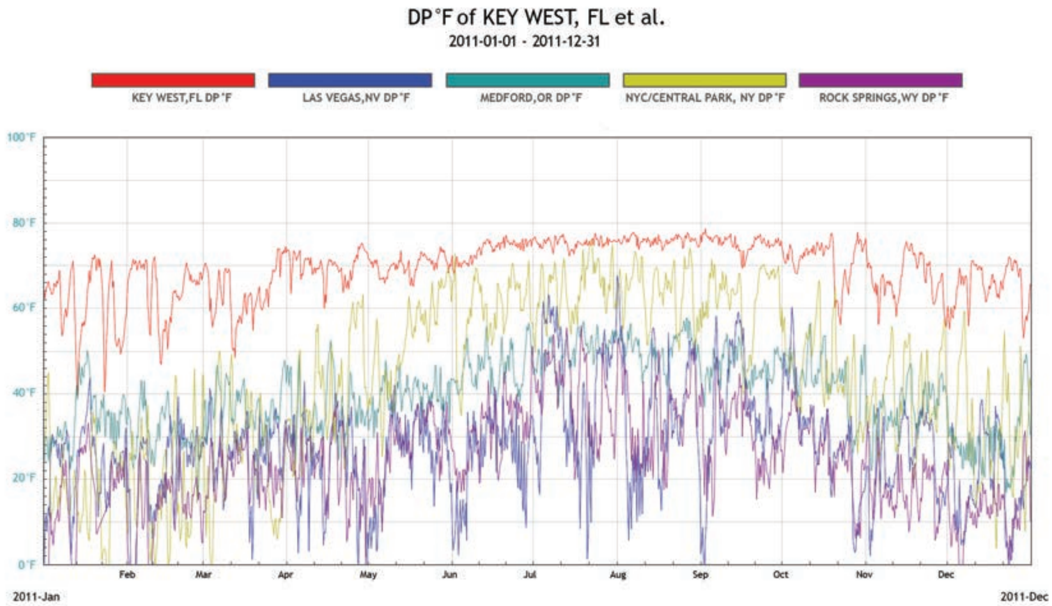


Relative humidity trends over the year will be a function of temperature and dew point. In many temperate areas the shape of the temperature and dew point graphs are similar, peaking in the summer when air is hot and holds lots of moisture. The opposite is true in winter when air is generally cool and dry. In tropical locations the dew points are high all year long, the temperatures are uniformly quite warm, and the RH line is flatter in shape over the year and consistently high.

The following graph shows a full year of relative humidity data from the same five locations. It shows both the extreme differences in outdoor RH between regional climates and the large daily variation of outdoor RH caused by daily variations in temperature.



The final graph shows a full year of outdoor dew point data from the same five locations. It clearly shows the large variations in moisture content of outdoor air from different climatic regions. Remember that it is this moisture that the mechanical system has to manage, avoiding dangerously high or dangerously low levels of moisture in the environment.



The table that follows provides an overview of the average temperature, relative humidity, and dew point temperature for each of the cities illustrated in the preceding graphs.

City	Start Date	End Date	Avg. Temp	Avg. RH	Avg. Dew Point
Key West, FL	1/1/11	12/31/11	78°F	75%	69°F
Medford, OR	1/1/11	12/31/11	53°F	66%	40°F
New York, NY	1/1/11	12/31/11	56°F	66%	43°F
Rock Springs, WY	1/1/11	12/31/11	43°F	55%	25°F
Las Vegas, NV	1/1/11	12/31/11	69°F	27%	28°F

A review of the environment in your locality is the best way to understand your building's mechanical system performance and begin to evaluate the preservation quality of the environment your collections are stored in. This is done by comparing graphs of local outdoor environmental data with data collected within the storage space during the same period. A comparison of the dew point temperature data is particularly informative (see Section 6C for more).

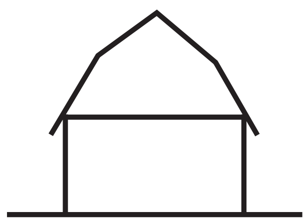
2B The Building Envelope

The building envelope provides the first level of protection against the outdoor environment. It includes all of the elements that mediate between the indoors and outdoors, including the roof, doors, walls, windows, chimneys, and other above-grade components. The building envelope also encompasses below-grade components such as basement walls, floors, crawl spaces and insulation. Among the environmental factors that the building envelope mediates are thermal gains and losses from conduction and solar radiation and moisture gains and losses of water vapor, liquid water and soil moisture.

Building Classifications

Ernest Conrad of Landmark Facilities Group, Michael C. Henry of Watson & Henry Associates, Richard Kerschner, Chief Conservator at the Shelburne Museum in Vermont and others frequently refer to the following building classifications:

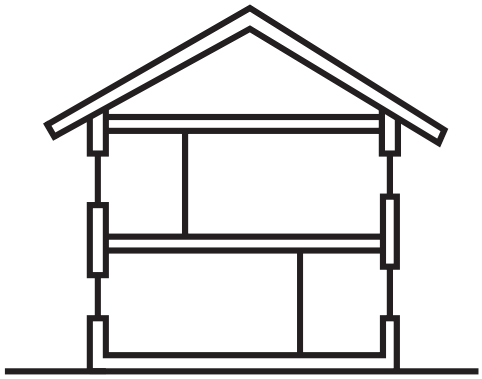
CLASS ONE BUILDINGS
Open structures (shelters, lean-tos)



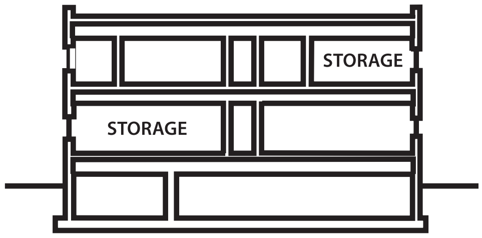
CLASS TWO BUILDINGS
Sheathed post and beam structures, wood or metal-clad wood frame buildings (sheds, barns, cabins, mills)

CLASS THREE BUILDINGS
Wooden structures with framed and sided walls and single glazed windows or un-insulated masonry structures, with shallow crawl spaces or basements (standard historic house types)

CLASS FOUR BUILDINGS
Tightly constructed wooden structures or heavy masonry structures with composite plastered walls, single glazed or storm windows (typical high quality historic houses; residential, education, civic and religious buildings)

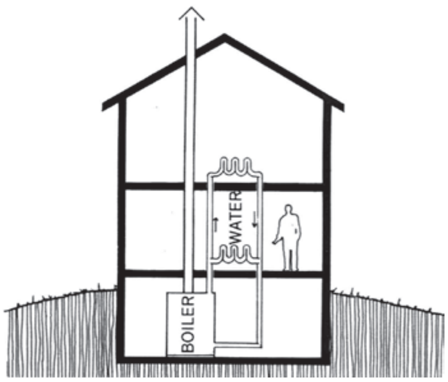


CLASS FIVE BUILDINGS
Newly-built structures with metal or concrete frames, tight construction with insulated walls, vapor barriers and double glazed windows (museums, libraries, office buildings, storage and industrial buildings)



CLASS SIX BUILDINGS
Rooms-within-a-room, double wall construction with insulated and sealed walls (storage vaults specially built to support precision environmental control)

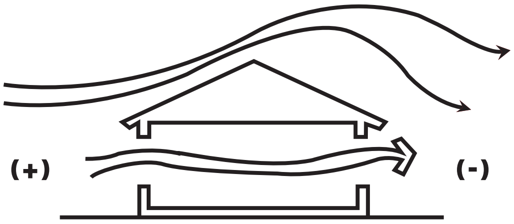
A Brief History of Heating and Ventilation

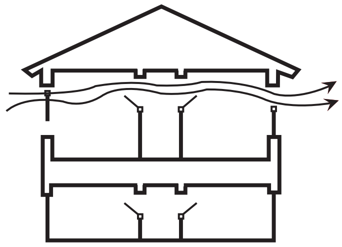


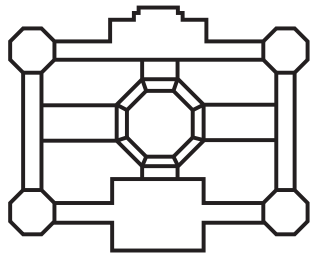
Peter Herzog, architect and energy efficiency expert with Herzog/Wheeler & Associates in St. Paul, Minnesota, provides an overview of the evolution of building design and climate control through the following illustrations and information:

One of the primary reasons why humans created buildings was to help keep out the elements—rain, snow, wind, and cold. Heat was provided by building a fire in the space where heat was desired – evolving from a fire pit, to a fireplace, and finally to a stove. All of these require bringing a fuel source into the space and providing a means of exit for smoke and other products of combustion. A major step in the evolution of heating systems came with the invention of a method to locate the heat-producing fire somewhere remote from the space to be heated, and to provide heat to multiple spaces from a single remote fire. These systems consist of a boiler or furnace to contain the combustion and employ steam, hot water or heated air as a means of conveying the heat to the desired location. By the late 19th century, steam and hot-water radiators had replaced fireplaces and stoves as the source of heat in many spaces.

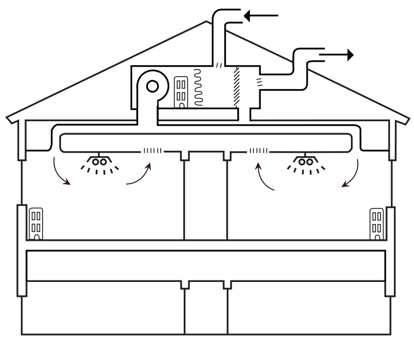
Windows, designed to let in light, also provided ventilation. Building design allowed for this ventilation by including double hung windows and transoms above doors. However, this only works if the building is no more than two rooms wide.







In the early stages of this evolution, large buildings included courtyards or were designed in T or H-shapes to accommodate the need for air flow through the space and provide access to daylight in every room. Eventually, use of electricity allowed for a constant source of ventilation with the incorporation of fans, designed to let outside air in and take inside air out.



Electricity provided a constant source of light, and facilitated control of heating, ventilation and air conditioning. Forced air heating systems with ducts and registers allowed the configuration of buildings to change. Central air conditioning was introduced in the 1920s and by mid-century forced air systems with combined heating and air conditioning using the same ductwork were available.

The development of high-rise buildings, heating and air conditioning systems and full service electric lighting exploded after WWII. Today's buildings are no longer dependent upon their perimeter for light and air, and they are sealed from the exterior and "breathe" through their climate control or HVAC (heating, ventilating, and air conditioning) systems. The outdoor climate still matters – all the air coming into the building comes from the outside, along with the heat, the cold, and the moisture level.

2C Mechanical Systems

Common mechanical systems and the challenges and opportunities they provide for managing the environment for preservation can be reviewed based on the building classification (described in 2B), as noted below:

CLASS ONE BUILDINGS

Buildings generally have no mechanical system and have little or no potential for environmental improvement.

CLASS TWO BUILDINGS
Buildings normally offer only ventilation (windows and doors) to reduce heat and moisture accumulation. There are usually no vapor barriers or insulation. There is minimal difference between the indoor and outdoor environment.

CLASS THREE BUILDINGS
Buildings usually lack insulation or vapor barriers. These buildings tend to have mechanical systems designed to provide temperature control only (radiator heat for example) with no ability to control humidity. Periods of low RH can dry and crack historic surfaces. High RH can cause moisture to collect or migrate into walls, resulting in rotting wooden elements, rusting metal surfaces, efflorescence and salt deposits on masonry, mold outbreaks, and peeling paint.

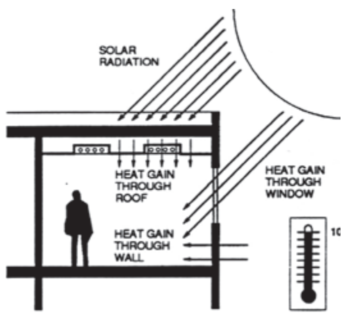
CLASS FOUR BUILDINGS
Buildings may have attic insulation but generally don't have vapor barriers. These buildings often have a ducted system of heating and cooling which may be capable of low-level heating and limited humidification in winter, cooling and re-heating for dehumidification in summer.

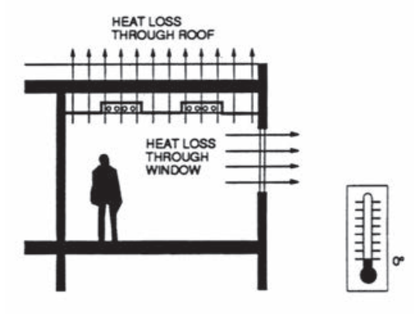
CLASS FIVE BUILDINGS
Buildings have well-insulated walls and roofs, vapor barriers, and double-glazed windows. They can support complete HVAC systems with winter comfort heating and humidification, summer cooling and re-heating for dehumidification.

CLASS SIX BUILDINGS
Buildings are well-insulated and sealed to support precision controlled heating, cooling, and humidity control systems.

Basic Environmental Management

The forces that affect indoor climate are primarily related to the building envelope. In summer, interior spaces can be affected by heat conducted through exterior walls and roofs, by solar radiation through windows, and by the infiltration of outside air through openings in the building envelope. Similarly, in winter, conduction and infiltration can cause interior spaces to become cool.

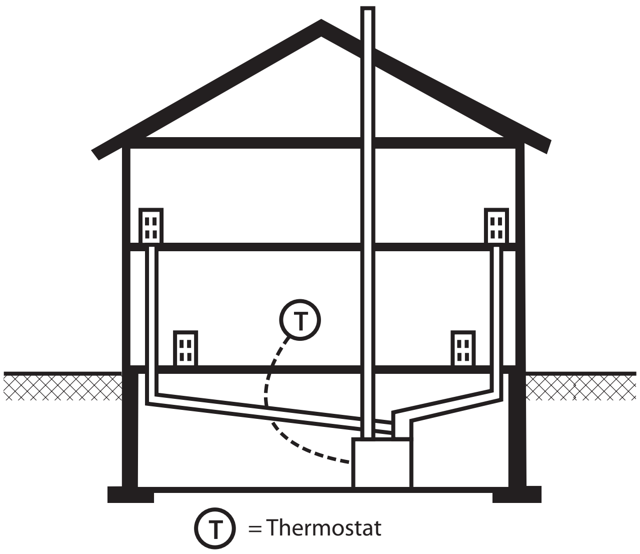




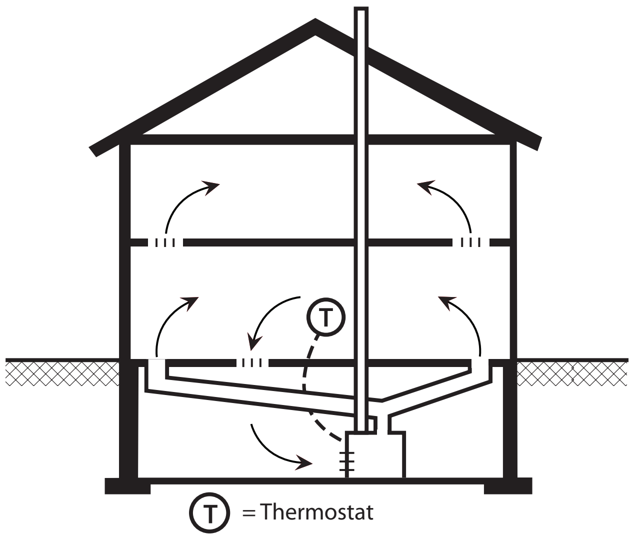
Simple modifications can be employed in buildings without sophisticated mechanical systems. You can limit solar gain by using shades and shutters and reduce heat gain and loss by adding insulation wherever possible. Portable climate control equipment including humidifiers, dehumidifiers, heaters, and air conditioners can be used to manage extremes of relative humidity and temperature. It is important to eliminate sources of moisture by repairing leaks, replacing damaged gutters and downspouts, and correcting drainage problems.

Mechanical Systems in Class Three and Four Buildings

Buildings with heating only, supplied by a hot water or a steam boiler, typically have a single thermostat that tells the boiler when to operate. Often the temperature in rooms other than the one where the thermostat is located will be indirectly controlled. Some systems however do provide the ability to control the temperature in each individual room by thermostatically controlling the flow of hot water or steam to individual radiators or convectors. These systems have no ability to control moisture. Portable humidifiers or dehumidifiers can be used to control relative humidity in individual spaces.



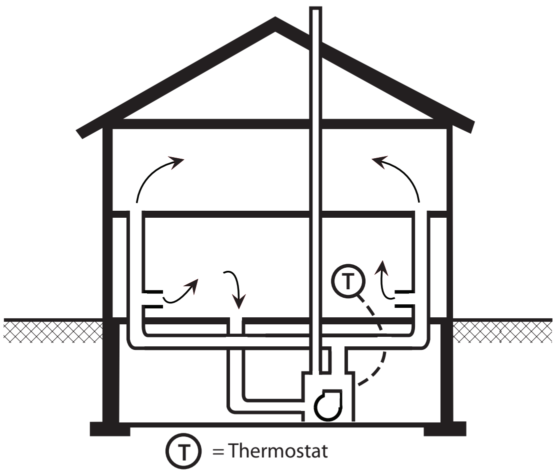
Boiler - Hot Water or Steam



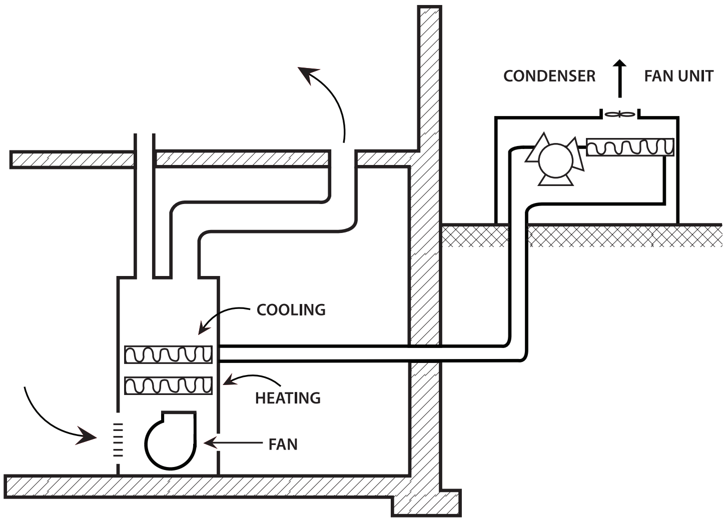
Gravity Furnace

Buildings with forced air furnaces supply heat by ducting a stream of hot air to each space to be heated. The furnace typically operates to satisfy a thermostat located in one space. The temperature in all other heated spaces is indirectly controlled by manipulating manual balancing dampers to adjust the portion of heated air that enters each space. A humidifier can be installed at the furnace and controlled by a humidity sensor that measures the relative humidity of the air returning to the furnace from the spaces. There is no ability to control the relative humidity of individual spaces.

Cooling capacity is commonly added to these systems to deliver cooled and dehumidified air to the spaces through the same ducts. It consists of an evaporator (cooling) coil in the air stream to absorb the heat, and a condenser/fan unit located at the exterior to reject the heat outside.

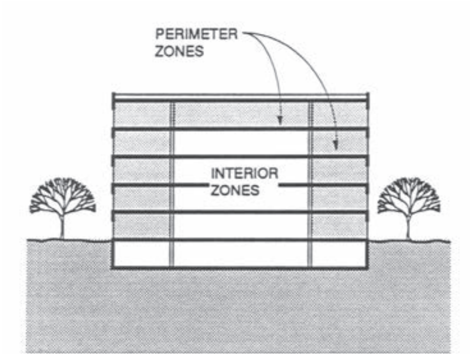


Forced Air Furnace with Electric Fan

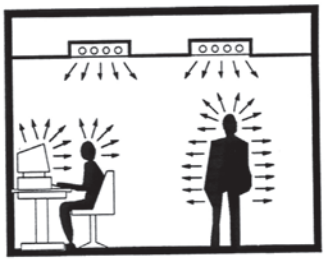


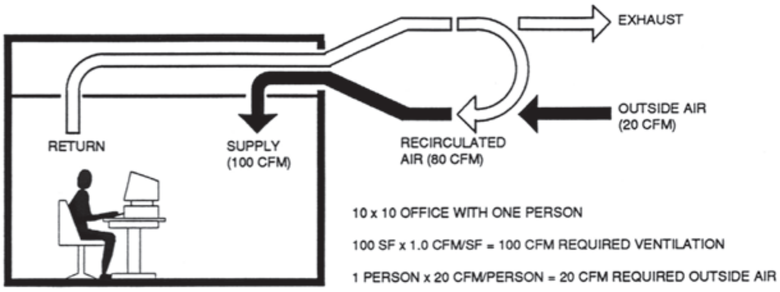
Forced Air Furnace with Cooling—Fuel plus Electricity for Fan, Compressor & Condenser

Mechanical Systems in Class Five and Six Buildings



The forces that affect indoor climates in Class Five and Class Six buildings include the same heat gain and heat loss through the building envelope as previously explained, but they also gain heat from internal sources. Since these buildings do not depend on exterior walls for light and ventilation, many spaces have little or no exposure to the building envelope and may be partially or entirely surrounded by tempered spaces. In these cases, spaces are unaffected by outdoor weather, but must deal with internal forces such as people, lights, and equipment that all produce heat. For these buildings the need to accommodate fluctuations in outdoor conditions is entirely driven by the amount of outdoor air purposely brought into the spaces.

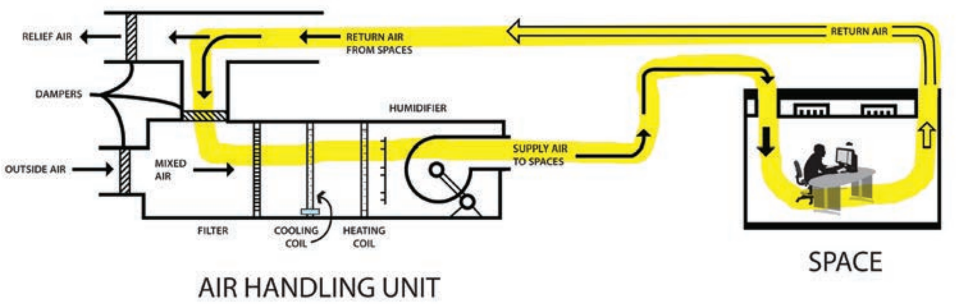




Storage spaces in Class Five and Class Six buildings are generally isolated from their surroundings, and all of their climate control needs must be met by their heating, ventilation and air conditioning (HVAC) system. These systems are designed to constantly move a stream of air through the space as a means of conveying heat and/or humidity into or out of the space as required. A fraction of this air stream typically consists of fresh outdoor air and the remainder is recirculated.

The Loop—Components of a Typical Air Handling Unit (AHU)

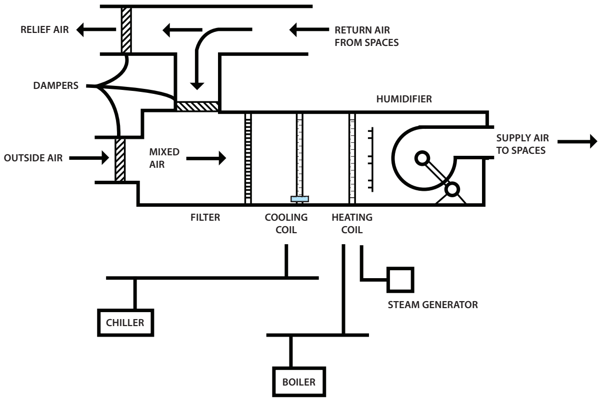
Climate control systems can best be understood if they are conceived of as a moving loop of air that enters the space, passes through it, leaves the space, returns to the place where the conditions of that air are appropriately altered (air handling unit) and returned again to the space (see diagram below). It is along this loop of moving air that temperature can be raised or lowered, humidity can be raised or lowered, filtration can occur, and outside air can be added or removed.



There are several typical components of an AHU, and each can alter the conditions of the moving loop of air, and ultimately the environment in the space. These components are described below.

SUPPLY AIR FAN

The energy to move the loop of air is supplied by a fan powered by an electrical motor. It pushes the air out to the spaces through the supply air ducts and draws it back through the return air path. In some systems a second fan is employed to assist with pulling the return air back to the AHU. Most fans serving collections spaces operate at a constant speed. However, some are equipped with variable speed drives that allow you to adjust the speed at which the volume of air in a space is exchanged.



Air Handling Unit with Peripheral Elements

HUMIDIFICATION

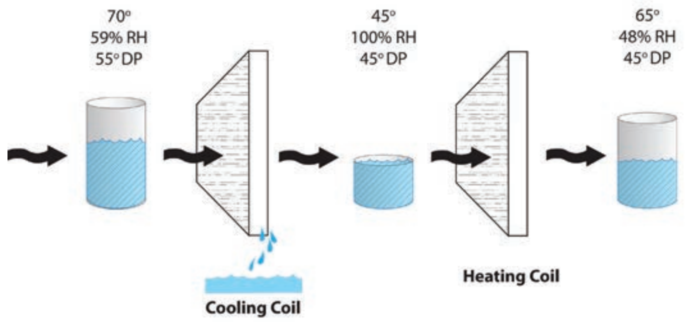
If a sensor, usually in the return air stream, detects that the space relative humidity is too low, the humidifier injects water vapor into the supply air stream. This water vapor is typically in the form of steam that is produced by a small steam generator (peripheral to the AHU) heated by steam, electricity, or gas.

HEATING

Heating is provided to spaces by passing the stream of air over a warm heating coil and conveying that air to the space. Heating coils are controlled by a thermostat. Hot water or steam produced by the boiler (peripheral to the AHU system) allows the selected temperature to be achieved in air passing through the heating coil. On occasion heat may be introduced to a space directly using convectors or radiators.

COOLING AND DEHUMIDIFYING

If a sensor in the space detects that the space is too warm, the stream of air is passed through a cold coil before being supplied to the space. The coil is cooled by a flow of cold water supplied by a chiller (peripheral to the AHU system) or by the evaporation of a refrigerant provided by a remote compressor/ condenser unit (known as DX cooling). If the temperature of the cooling coil is below the dew point temperature of the air, moisture will condense on the coil, thereby dehumidifying the air. In cases where the desired space dew point temperature is quite low (e.g. 45°F) at least some of the air must be cooled to 45°F. Because 45°F is colder than the desired space temperature, this sub-cooled air must be reheated. Such arrangements are called sub-cool/reheat systems.



Dehumidification by Sub-cooling and Reheating

Some buildings have humidistatically controlled systems, which are designed to maintain a stable RH by manipulating and varying the temperature. A humidistat sensor adjusts the temperature up if the RH rises above a set point, and maintains it until the RH drops back. If interior RH is lower than exterior RH, dampers are opened by sensors and the air is circulated through the building. If exterior RH is too high, the dampers remain closed.

AIR FILTRATION

Air filtration is provided by passing all air delivered to spaces through one or more filters to remove particulates. Often additional filters are added to remove gaseous components in the air. In some systems the outside air is separately filtered as it enters the system.

MIXED AIR CONTROL

As the air from the spaces returns to the AHU a portion of that air is ducted outside (through the relief air damper) to make room for the introduction of fresh air through the outside air damper. Systems are typically designed to constantly introduce 10% to 15% outside air. This outside air is blended with the bulk of the return air in the mixed air chamber.

In some systems there is no process for relief air at the AHU. Instead, a volume of air equivalent to the outside air is allowed to exfiltrate from the spaces in order to keep them positively pressurized and thus avoid the infiltration of air from surrounding spaces.

SYSTEM CONFIGURATION

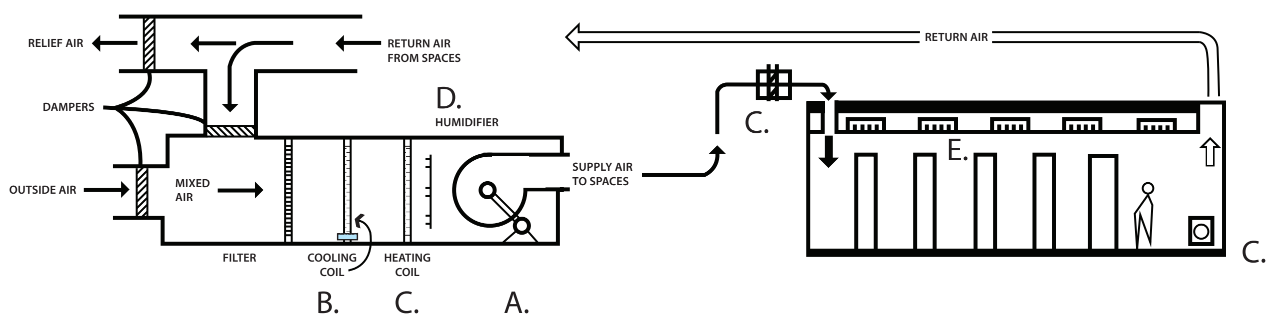
Buildings often have multiple HVAC systems and these systems commonly serve multiple spaces. It is important to document each storage area's HVAC system and all of the spaces served by it. Some systems have devices that can alter the condition of the air as it enters individual spaces. One example is a thermostatically controlled damper that can vary the volume of air entering the space – a variable air volume (or VAV) box. Heating coils are another example. Some systems have both variable volume and heating coils.

LIMITING THE AMOUNT OF OUTSIDE AIR CAN SAVE ENERGY!

It should be noted that, in Class Five and Class Six buildings, the need to humidify and dehumidify is directly related to the quantity of outside air admitted into the system. This is because the moisture content of the outside air (and therefore its dew point temperature) is almost always higher or lower than the desired storage space air moisture content (and dew point temperature). Read more in Section 9C.

2D Energy Use in the Storage Environment

Collection storage areas are usually maintained at more stringent temperature and humidity conditions than other spaces and as a result these spaces consume more energy than other areas. As a result facility managers and administrators are looking to collection care staff to consider energy-saving alterations to the operation of HVAC systems serving storage areas. The primary energy-consuming elements of a typical forced air HVAC system include the following:



A. Air Handling Fans B. Cooling Coil C. Heating Coil D. Humidifier E. Lighting

Air Handling Fans (A)

An air handling fan powered by an electrical motor provides the force necessary to move the air stream around its loop path from the AHU to the spaces served, back to the AHU and through various filters and coils. Some units have two fans, one to supply the air as shown above, and a second one to assist in pulling the return air back to the AHU. Most collection area AHU fans operate continuously and most run at a constant speed. Some are equipped with variable speed drives, and therefore it is possible to operate them at less than full speed based on a schedule or some sensor input. The factors that determine how much energy an existing fan motor will use are:

- Motor size (watts consumed at full load)
- Speed of operation
- Hours of operation

Cooling Coil (B)

Cooling coils absorb heat energy that is conveyed from the coil to chilling equipment to reject that heat to the air outside. The warmer and moister the outside air is, the more electrical energy the cooling system requires to reject heat into it. While there are a number of factors within the chilling system that affect its efficiency and energy consumption, the key factors that affect the amount of cooling work (and therefore the cooling energy consumption) at the cooling coil are:

- The temperature and RH of the air returning to the AHU (heat gains at spaces served)
- The temperature and RH of the outside air (dew point temperature)
- The amount of outside air
- The total amount of air cooled / dehumidified
- The temperature and RH of the air after the cooling coil (related to space temperature and RH set points)
- Annual hours of operation

Heating Coil (C)

When heat is required, the stream of air passing over the heating coil picks up heat. Air passing over an otherwise ambient temperature heating coil can be heated by introducing some source of heat (steam, hot water, electrical resistance) into the coil. The steam or water is heated by a boiler located somewhere remote from the AHU. The ultimate source of this heat is the combustion of some fuel (natural gas, fuel oil, coal) or electrical resistance heat. Like chilling systems, boiler systems have a number of factors that affect their efficiency and energy consumption.

The key factors that affect how much heating energy is consumed at the heating coil are:

- The temperature of the air returning to the AHU (heat losses at the spaces served)
- The temperature of the outside air
- The amount of outside air
- The total amount of air heated
- The temperature of the air after the heating coil
- Annual hours of operation

Humidifier (D)

Whenever the relative humidity of the air returning from the storage spaces is lower than the set point, the humidifier injects water vapor into the air system. This usually takes place just before the air leaves the AHU. Some humidifiers inject moisture into the air stream in the form of steam originating from a central steam system, or from a small dedicated steam boiler heated by gas or electricity. Other humidifiers atomize water using ultrasonic waves, or by forcing the water through small nozzles at high pressure. The energy required to atomize the water varies considerably, with boiler-heated steam being the most energy-consuming, and the ultrasonic vaporization among the least energy intensive systems.

It should be noted that humidification typically represents less than 7% of the annual energy consumed by a storage space HVAC system, even in northern climates where winter-month humidification needs are the highest. The factors that determine humidifier energy consumption are:

- The absolute humidity (dew point temperature) of the outside air
- The amount of outside air
- The space temperature and RH set point (and corresponding absolute humidity)
- Hours of operation

Lighting (E)

Lighting can be a significant contributor to total annual energy consumption. As the illustration on p.26 shows, a storage area's climate control system can be conceived of as a loop of moving air that connects a number of locations where energy is consumed. Lighting can be a significant contributor to total annual energy consumption depending upon the total watts of installed lighting and the hours of operation. The energy consumed to produce light also produces an equivalent wattage of heat that is carried by the return air stream to the AHU, where it typically must be removed by the cooling coil.

Summary of Energy Consumption

While the annual cost of energy to provide a storage area's climate control will vary widely depending upon system configuration, current utility rates and region of the country, the following allocation for a typical system in a "Continental Climate" zone (p.17) will provide some perspective on the contribution each component makes to the total annual cost of energy.

Component	% of Annual Energy Cost
A. Air handling fans	19%
B. Cooling coil	30%
C. Heating coil	40%
D. Humidifier	5%
E. Lighting	6%

In existing collection storage mechanical systems, factors such as weather, the building envelope and the configuration of the AHU, are relatively fixed and not capable of manipulation in the interest of energy use reduction. However, there are several factors subject to manipulation that can significantly affect energy consumption. These include temperature and RH set points, quantity of outside air, total air flow, and hours of operations. Chapter 9 discusses energy saving opportunities in more detail.

2E Institutional Stakeholders

Section one of this guidebook is focused on what you need to know to define an optimal and sustainable preservation environment. We've pointed out that you need good background information about the collections in your institution and how they react to the environment, you need to understand all the elements that determine the climate in the storage area, and you need to know what opportunities for energy savings should be considered. The next step is to identify who you need to involve to gather this information and negotiate the optimal environment? Who are the institutional stakeholders?

Create an Environmental Management Team

In order to make changes to the current environment that truly have an impact, it's important to include people who affect and create the storage environment in the process. We recommend a cross-functional team with at least one permanent representative from collection care (conservation, collection management, curatorial, preservation), and one or more from facilities (engineers, building operators, facility managers). You may also need someone in an administrative capacity on the team. Often large institutions or college campuses have someone assigned to sustainability and energy savings, and this person should be asked to join the team. These individuals should be considered representatives of their co-workers and areas of responsibility, with an obligation to present their concerns and report back on team discussions and decisions.

The work of the Environmental Management Team should be considered an ongoing activity, ideally with someone assigned as a champion of the task and with long-term administrative support. Representatives from Facilities bring their knowledge of building operations, and mechanical system functions and capabilities. Collections representatives have generally monitored the environment and have collected data to review, and know where the most vulnerable materials are stored. The Administrative team member should be someone who can affect activities within the storage area, can enforce changes in routines or functions as needed, and can get funding for equipment if needed.

Collections staff are used to a management approach that includes asking for specific set points and parameters, then watching for excursions outside of these limits. Facilities staff are used to being told what environment is needed, and then reacting to emergencies and comfort complaints. The Environmental Management Team should develop a new approach to managing the environment which will be a collaboration, a sharing of information, and a negotiation. The goal is to define an optimal and sustainable preservation environment that is:

- Best for the collections in your institution
- Achievable given your regional climate, your building and its mechanical system
- Acceptable to the occupants of the space
- The least energy-consuming

Managing the environment has an effect on the fiscal health and everyday working life of the institution. The capital expense, increasing energy costs, and other operating expenses associated with providing heating, cooling and ventilation have a significant impact on institutional budgets. At the same time, the value of institutional collections cannot be overstated and the responsibility to provide adequate stewardship is primary. As we have noted, the storage environment plays a significant role in the ability to preserve collection material over the long term. An effective solution to managing the environment to achieve both collection preservation and energy efficiency can only be achieved if environmental management is a team effort. IPI's experience has shown that most institutions can improve the preservation of collections and contain energy costs when the right people work together to understand, evaluate, and improve the environment in their institution.

A growing body of research suggests that institutions can more easily develop effective and affordable preservation measures, particularly those that manage the environment surrounding collections, by undertaking collaborative and interdisciplinary planning. We therefore encourage interdisciplinary planning that analyzes collections and their current conditions and risks, the characteristics of the building that houses the collections, energy usage and environmental impact, and local climatic conditions.

National Endowment for the Humanities, Sustaining Cultural Heritage Collections FAQs, http://www.neh.gov/grants/guidelines/SCHC faqs.html