Planning Successful Rehabilitation Projects

Interiors

Identifying Primary and Secondary Interior Spaces in Historic Buildings

This document provides guidance on identifying and evaluating significant elements in the interior of a building, to clarify those elements that must be retained or minimally modified in a rehabilitation project, and those that can undergo greater change or modification.

This process has already been covered in some detail in Preservation Brief 18: Rehabilitating Interiors in Historic Buildings. This document complements that guidance, drawing from its terminology and general approach while providing more specific steps and questions it may be useful to ask, as well as a section covering typical elements to consider in specific building types.

A thorough evaluation of all historic elements of a building in the planning stages of a project will help ensure that the project can be completed successfully by maintaining the building's historic character. Following the guidance below will help accomplish the evaluation. This review is part of a three-step process involving researching and documenting the building's history, evaluating the building's historic elements, and assessing changes to the building proposed in a rehabilitation project.

Evaluating the interior of a building involves two aspects: identifying which elements of the interior are historic, including those changes that have acquired significance; and evaluating the significance and physical condition of those elements. It is useful to note that determinations of historic significance for these evaluations are tied to the stated period of significance in the National Register nomination for the individual building or for the historic district in which the building is located.

Historic elements may be evaluated as either **primary** or **secondary**. Primary elements are those that are important in defining the historic character of a building and that should be retained or only minimally altered. Secondary elements are less critical in contributing to the historic character and may be able to undergo greater change without substantially impacting the building's overall historic character. It should be recognized that these elements are more likely to lie on a continuum of most to least important, rather than simply falling into one category or the other, and the amount of acceptable change will have an inverse relationship to that importance, depending on other factors such as physical condition.

Elements can be categorized as pertaining to the building's **plan**; the individual interior **spaces** or sequences of spaces; or architectural **features, finishes** or **materials** that may have sufficient importance and physical integrity to be retained or only minimally altered.

Differentiating between primary and secondary elements is very important. The following definitions may help in evaluating these elements.

Primary spaces are those that are essential in conveying the historic and architectural character of a building. They are most often associated with the primary use or purpose for which the building was designed or used during its period of significance and can vary greatly from building to building.

Where a public to private progression can be identified in the spaces of a building, the most public spaces will usually be the primary spaces. Entrance hall and parlor, and lobby and corridors are common examples of primary spaces. Similarly when spaces of a building vary in their architectural detailing, those that are the most elaborate are usually the primary spaces. This is not to say, however, that a private space or a simple unornamented space cannot be primary.

Some buildings, such as churches, theaters or gymnasiums, contain single large spaces that accommodate the principal use. These are easy to identify as the primary space of the building.

However, in some buildings such as hospitals, apartment buildings or other buildings consisting of multiple units that serve similar functions, it may be the sequences and interrelationships of spaces that are most important in defining the character of the building. Such buildings must be evaluated carefully to determine the importance of all the related elements in the context of the building being

assessed.

Secondary spaces are less critical in defining a building's importance within its period of significance. They often still help define the building's significance and character, but because of their size, location, or function their impact is not felt as strongly when progressing through the building. Thus, altering these spaces may not significantly impair the ability of the overall building to convey its primary historic significance.

A secondary space is usually a more simply detailed space with restricted access – such as an office, hotel guestroom, or a bedroom – or a utilitarian space that serves a support function within a building – such as a kitchen or bathroom. Generally, these spaces are less architecturally detailed and subordinate in character to the primary spaces to which they relate.

The **physical condition** of interior elements will frequently affect their historic character and how they contribute to the historic significance of the building. If an interior plan has been heavily altered, it may no longer adequately convey its importance to the building's character, and further changes may be more acceptable. Conversely, if a bedroom in a rowhouse still retains many of its features such as moldings, fireplaces and doors, then significant alterations in the space may not be appropriate. And, while secondary spaces such as offices behind a corridor typically may be able to accept major plan changes, if features such as historic trim and woodwork around the perimeter wall of the building are still extant they should be retained.

To aid in evaluating the significance and integrity of each of these categories of elements it may be helpful to ask the following questions about a building's plan, spaces, features, and finishes and materials.. These are not comprehensive but, instead, suggest how an evaluation may proceed in order to cover the significant elements of any building.

Plans

Does the building have a floor plan that is an important characteristic of the building type, style, or period of construction or historic function?

Is the plan symmetrical and is this symmetry an important characteristic of the building type or style? Conversely, is the asymmetry an important characteristic?

Has the plan been altered over time? Have the alterations been additive (large rooms subdivided into smaller ones); or have the alterations been subtractive (walls removed)?

Does the plan retain its basic integrity?

Spaces

Are there rooms or spaces that are architecturally or historically significant?

Have rooms survived that are characteristic of the building type or style or that are associated with specific persons or patterns of events?

Is there a sequence of spaces that has been consciously designed or that is especially important to the understanding and appreciation of the building or the architect? Examples might include a foyer opening into a large hall; front and rear parlors connected by pocket doors; office lobby opening into an elevator hall; hallway to stairwell to upper hallway, etc.

Does the space have distinctive proportions – ceiling height to room size, for example?

Are the room shapes or volumes in any way unusual? Examples may include rooms with curved walls, rooms with six or eight walls, or rooms with vaulted ceilings.

Are the rooms a consciously designed "whole," that is, are the space, features, and finishes part of an integral design?

Have the spaces retained their architectural integrity, despite alterations and deterioration?

Do the spaces reflect the exterior design, e.g., tall windows indicating an assembly space on the second floor?

Features

Are there architectural details that are characteristic of the period of significance, construction or historic function? Examples might include wainscoting, parquet flooring, picture molding, mantels, ceiling medallions, built-in bookshelves and cabinets, crown molding, arches, as well as simpler, more utilitarian features, such as plain window and door trim.

Are there features that indicate later changes and alterations that have gained significance over time? Examples might include lobby alterations, changes to wall and floor finishes, and later millwork.

Are there features that were worked by hand, or that exhibit fine craftsmanship or are characteristic of the building style or type?

Have the features survived intact in one or more rooms?

Is the ceiling vaulted, coffered, decorated with plasterwork, domed, or otherwise embellished?

What is the condition of the features: can they be retained and preserved?

Finishes / Materials

Are there surviving historic finishes that can reasonably be retained and preserved? Examples might include plaster, tile, flooring, and marble?

What is the condition of the finishes, e.g., has water damage been so severe as to render the finishes unsalvageable?

Are there finishes such as graining that are characteristic of a period or style of architecture?

Evaluating Interior Elements – Typical Building Types

Certain building types tend to have common types of plans, spaces, features, and finishes; for example, most schools can be expected to have auditoriums and most rowhouses can be expected to have a front parlor. Assessing the importance and condition of these architectural elements is the essential component of evaluating any interior rehabilitation proposal.

In virtually all cases, a project will not meet the Secretary of Interior's Standards for Rehabilitation if, as a result of the rehabilitation, the interior has lost all vestiges of its past; in these cases, the sense of time and place has been lost that was associated both with the building and the district in which it is located. Radical transformations of the sequence of spaces, or of the trim and finishes can be justified only in exceptional cases, where the interior deterioration is so extreme that the building can be said to retain its significance only by virtue of a high degree of integrity on the exterior.

Listed below are major building types that are commonly rehabilitated, with general statements about the relative importance of architectural elements often found in them. The guidance is not intended to be comprehensive, but rather is intended to help make consistent decisions about interior rehabilitation treatments in keeping with the Standards for Rehabilitation. A certain degree of repetition may be noted from building type to building type – for instance, it is always recommended to retain historic window and door trim.

Houses, Rowhouses, and Duplexes
Apartment Buildings and Tenements
Shotgun Houses
Schools
Factories, Industrial Buildings, and Warehouses
Fraternal and Lodge Halls
Commercial Office Buildings
Churches
Hotels
Hospitals

Despite generalizations about certain building types, it is important to keep in mind that what may be an acceptable rehabilitation approach for one building may not be acceptable for another. For example, in one school, subdividing a simple, unadorned auditorium with no association with important persons or events may be an appropriate treatment, while in another, the elaborately detailed auditorium (space, features, and finishes) may warrant retention or minimal alteration. **It is also important to recognize that a plain, simply detailed 19th-century worker's house is neither more nor less significant than a highly ornamented, high-style townhouse of the same period.** Both resources, if equally intact, deserve the same careful rehabilitation that respects the qualities for which designation as "certified historic structure" was granted.

Each evaluation is unique, taking into account the facts and circumstances of the building in question.

Houses, Rowhouses, and Duplexes

These elements tend to be character-defining interior elements and should be retained.

- Basic floor plan
- Features and details that are characteristic of the architectural style of the house
- Entertaining and living spaces, such as entry halls or foyers, parlors and dining rooms
- Primary staircase
- Floor-to-ceiling height in primary rooms
- Fireplaces, mantelpieces, and finishes on chimney breasts
- Architectural detailing including window and door trim, baseboards, picture rails, cornices, etc.
- Doors and windows
- Historic floors
- Historic hardware and fixtures, sometimes including lighting, radiators (if distinctive), knobs, pulls, and hinges

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Bedrooms, assuming the basic floor plan is retained
- Bathrooms and kitchens
- Secondary staircases
- Attached garages
- Utilitarian spaces such as closets and laundry rooms
- Basements and attics

Apartment Buildings and Tenements

These elements tend to be character-defining interior elements and should be retained.

- General plan of the building including location of hallways, circulation patterns, arrangement of apartments off central hallways (or entries)
- Overall character of design, spaces, details, and finishes–whether simple and utilitarian or highly decorative
- Historic public entrance(s) and lobbies
- Primary staircase(s)
- Elevator lobbies including space, features and finishes
- Corridors and doors off corridors
- Principal spaces within apartments, such as the foyer, living room, dining room, etc.
- Architectural detailing including window and door trim, baseboards, picture rails, cornice, etc.
- Doors and windows
- Historic floors

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Room dimensions, unless rooms are detailed or carefully proportioned
- Kitchens and bathrooms
- Utilitarian spaces such as laundry rooms, storage areas, boiler rooms, etc.
- Secondary staircases
- Secondary spaces within individual units

Shotgun Houses

These elements listed below tend to be character-defining interior elements and should be retained.

- Linear floor plan
- Sequence of spaces
- Basic floor-to-ceiling height
- Architectural detailing including window and door trim, transom lights, baseboards, etc.
- Doors and windows

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Kitchens and bathrooms
- Actual dimensions in rear rooms

Schools

These elements tend to be character-defining interior elements and should be retained.

- Historic public entrances
- Configuration and width of corridors
- Main staircases
- Generous floor-to-ceiling heights
- Auditoriums, gymnasiums or other large assembly spaces where space, features and finishes create an architectural statement or where the space is of historic importance
- Architecturally-detailed spaces such as the principal's office or library
- Unusual ceiling treatments such as vaults, coffers, etc.
- Architectural detailing including wainscoting, marble, beaded board, decorative plaster, window and door trim, baseboards, etc.
- Windows, doors, and transom lights

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Large assembly spaces that are not architecturally distinguished or historically important, or have been altered
- Secondary staircases
- Kitchens and bathrooms

- Utilitarian spaces such as cloakrooms, janitor's closets, boiler rooms, and storage areas
- Classroom size and actual room dimensions
- Blackboards

Factories, Industrial Buildings, and Warehouses

These elements tend to be character-defining interior elements and should be retained.

- Generous floor-to-ceiling height
- Structural systems such as wood beams, cast iron or steel columns, and truss systems
- Main stairs and stair towers
- Company offices
- Historic equipment, such as cranes and pulleys
- Architectural detailing including wainscoting, window and door trim, baseboards, etc.
- Doors and windows

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Full sense of open space if some sections are maintained
- Actual floor-to-ceiling height, if new ceilings are set above or significantly back from windows
- Secondary stairs

Fraternal and Lodge Halls

These elements tend to be character-defining interior elements and should be retained.

- Entrance, lobby and general arrangement of spaces
- Main meeting rooms
- Floor-to-ceiling height
- Main staircases
- Proscenium arch and stage
- Architectural detailing including wainscoting, ornamental ceilings, wall finishes, window and door trim, baseboards, fireplace mantels, etc.
- Windows and doors
- Historic floors

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Secondary or altered meeting spaces
- Secondary staircases
- Kitchens and bathrooms
- Utilitarian spaces such as storage areas, coat rooms, etc.

Commercial Office Buildings

These elements tend to be character-defining interior elements and should be retained.

- Historic corridor plan, including upper floors
- Historic public entrance(s) and lobby
- Main staircases
- Elevator lobbies: space, features and finishes (including upper floors)
- Executive office suites, board rooms, other meeting rooms and banking rooms
- Generous floor-to-ceiling heights
- Office doors, particularly those with transom lights above
- Light fixtures in public spaces
- Windows in corridors
- Architectural detailing including elevator doors, ornamental ceilings, wainscoting, wall finishes in public areas, window and door trim, baseboards, etc.
- Doors and windows

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Full length of corridors
- Office wall partitions on upper floors, if undistinguished architecturally
- Exact floor-to-ceiling heights on upper floors, if new ceilings are set above or significantly back from windows
- Secondary staircases

- Utilitarian spaces such as storage rooms, boiler rooms, etc.

Churches

These elements tend to be character-defining interior elements and should be retained.

- Historic public entrance(s) and vestibule
- Sanctuary space and volume
- Balcony
- Vestry hall
- Stairs to balcony space
- Doors and windows (configuration, size, and glazing)
- Architectural detailing including columns, ornamental ceilings, flooring, lighting fixtures, stairways, wainscoting, window and door trim, baseboards, etc.

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Secondary public spaces
- Sunday school classrooms
- Sacristies
- Fellowship halls
- Offices
- Kitchens and bathrooms
- Utilitarian spaces such as storage rooms, coat rooms, boiler rooms, etc.

Hotels

These elements tend to be character-defining interior elements and should be retained.

- Historic public entrance(s) and lobby
- Configuration and width of corridors
- Main stairs and elevator lobbies
- Commercial arcades on ground floor
- Floor-to-ceiling heights on ground floor
- Main ballrooms and reception rooms
- Architectural detailing including registration desks, columns, lighting elements, fountains, fireplaces, mantels, ornamental ceilings, wainscoting, door surrounds and transoms, window trim, baseboards, etc.
- Doors and windows

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Full length of corridors, depending on circumstances
- Secondary gathering spaces
- Individual guest rooms off corridors
- Service elevators
- Secondary staircases
- Kitchens and bathrooms
- Utilitarian spaces such as service pantries, laundries, coatrooms, service corridors, etc.
- Parking facilities

Hospitals

These elements tend to be character-defining interior elements and should be retained.

- Historic public entrance(s) and lobby
- Reception office or alcove
- Main stairs and elevator lobbies
- Configuration and width of corridors
- Entrances to wards
- Daylight rooms or solariums
- Chapel
- Operating theaters
- Dining rooms
- Floor-to-ceiling heights in public areas
- Architectural detailing including decorative plaster, ornamental ceilings, columns, wainscoting, chair rail, window and door trim,

baseboards, etc.
- Historic floors, such as terrazzo
- Windows and doors

These elements tend to be of less importance and may be able to accept greater intervention in the process of rehabilitation.

- Full length of corridors, depending on circumstances
- Secondary staircases
- Ward or room dimensions
- Operating rooms
- Cafeterias
- Kitchens and bathrooms
- Utilitarian spaces such as laundries, boiler rooms, and storage rooms

Additional guidance »

Preservation Brief 18: Rehabilitating Interiors in Historic Buildings – Identifying Character-Defining Elements

Preservation Brief 17: Architectural Character – Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character.

Planning Successful Rehabilitation Projects

Interiors

Subdividing Assembly Spaces in Historic Buildings

Public assembly spaces in buildings such as churches, theaters, schools, sports arenas, fraternal lodge halls, and hotels are typically the most significant interior spaces in these buildings, and proposals for subdividing them must be carefully evaluated in the context of an overall rehabilitation. As a first step, the most successful approach in these situations is to consider a use for the space that maintains the public or group activity nature of the space, in order to minimize the need for subdivision.

The following criteria come into play when making an evaluation of how much change these spaces can accommodate and how to approach subdividing them. These considerations interact and should be taken collectively, to make a balanced assessment of the impact of proposed changes.

Role of the space in defining the character of the building

In buildings such as churches and theaters, the assembly space is usually of paramount importance and the entire building is often defined largely by its interior space. Consequently, it can be difficult to subdivide such spaces without impacting the character of the building as a whole.

Other buildings such as schools or hotels may have several public assembly spaces, and they may not all be of equal importance. The subdivision of one assembly space may have less impact on the overall building, depending on its relative prominence. For example, in a school with an intact auditorium, gymnasium and cafeteria, subdividing the cafeteria would likely be less of an issue than a similar treatment in the auditorium.

Spaces should be evaluated for their importance architecturally in the building, as well as functionally. If an auditorium or lodge hall is expressed on the exterior of the building with double-height windows, for example, that speaks to its significance in the spatial hierarchy of the building. The space may still be character defining without that expression, but its existence is an indication of the primary nature of the space.

Physical layout and condition

The physical arrangement of the interior may help dictate the most appropriate options for subdivision. Even primary assembly spaces may have secondary areas such as a stage behind a proscenium or the area under a balcony. In some cases these areas can be walled off with little impact on the overall space, depending on other factors such as relationship to the larger space, dimensions of the area and degree of architectural detail. Conversely, it will be harder to divide spaces with areas that are of equal importance, or spaces with a more tightly unified design, such as a church sanctuary with a strong axial plan.

As in other areas of the interior, the existing physical integrity also will influence how much change the space can accommodate. If finishes and features are deteriorated or missing or if the space has already been significantly altered, then its importance in defining the character of the building may be diminished enough to allow further changes. However, the impact of new alterations must be evaluated in the context of what integrity does still exist, the functional or architectural importance of the space in the building, and other proposed project treatments.

Manner of subdivision

The manner in which the space will be subdivided must also be considered. Treatments such as adding full-height walls or new floors that block the sense of volume of the space do not meet the Secretary of Interior's Standards for Rehabilitation, unless the space is a secondary or tertiary area in a building with other more important public rooms. However, divisions that do not intrude on the overall character and height of the interior may be appropriate. Lower partition walls in the main space, such as open office-height partitions in a two-story space, may be used in some instances. Also, in certain situations it may be possible to insert a mezzanine into secondary areas, if it has only a minimal impact in the space.

Existing historic features and finishes should also be retained to the maximum extent possible, and new vertical or horizontal partitions should not diminish their prominence and impact. For example, a new wall between a stage and auditorium space that is installed behind the proscenium rather than within the opening will keep the appearance of the stage boundary dominant.

For more general guidance regarding changes to interior spaces, please refer to **Changing Secondary Interior Spaces in Historic Buildings**.

Additional guidance »

Preservation Brief 18: Rehabilitating Interiors in Historic Buildings – Identifying Character-Defining Elements

Preservation Brief 17: Architectural Character – Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character.

Planning Successful Rehabilitation Projects

Interiors

Changing Secondary Interior Spaces in Historic Buildings

Secondary interior spaces are less critical in defining a building's importance than the primary spaces. They often still help define the building's significance and character, but because of their size, location, or function their impact is not felt as strongly when moving through the building. Altering these spaces may not significantly impair the ability of the overall building to convey its primary historic significance. (Refer to **Identifying Primary and Secondary Spaces in Historic Buildings** for more information.) Therefore, secondary spaces offer more opportunities for change and alteration compared to what is allowed in primary spaces. Appropriate changes may range from removal of existing partitions and addition of new partitions, to insertion of new floors, cutting openings in existing floors or ceilings and other modifications depending on the location and condition of the space. The opportunities and limitations for change must be identified within the following context.

Spaces may be subdivided both vertically through the insertion of new walls or horizontally through the insertion of new floors or mezzanines. New vertical or horizontal divisions must not intersect or alter the interior or exterior appearance of existing windows, doors, or other architectural features, especially when these changes can be seen from primary spaces or visible exterior elevations. Even if secondary spaces are subdivided, historic architectural features and finishes that contribute to the character of the space should be retained.

Secondary spaces that have been previously modified and lack important architectural features or finishes allow greater opportunity for change. New modifications must not alter the historic character of the space. New treatments that require removing all existing finishes, whether historic or not, and exposing structural elements in buildings where this is not in keeping with the historic appearance of the property's interior are not appropriate. Conversely, creating highly decorated or elaborate interior rooms and spaces in buildings that were historically devoid of such features is also not appropriate.

New floor openings must generally be contained within secondary spaces and be of a limited size. New stairs to provide a secondary means of egress may be placed within secondary spaces. However, a new floor cut must be placed away from exterior walls, particularly if there are windows and other openings in the wall through which the new floor cut would be visible from a public right-of-way. In addition, floor cuts should leave portions of the floor in place around the new openings and should appear as cuts into existing floors, not as a wall-to-wall removal of floor material that leaves a gap in the floor across the building.

In general, secondary spaces provide opportunities for change necessary to convert a building to a new use while maintaining its overall architectural character in accordance with the **Secretary of the Interior's Standards for Rehabilitation**.

Additional guidance »

Preservation Brief 18: Rehabilitating Interiors in Historic Buildings – Identifying Character-Defining Elements

Preservation Brief 17: Architectural Character – Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character

2 Preservation Briefs

Technical Preservation Services
National Park Service
U.S. Department of the Interior

Repointing Mortar Joints in Historic Masonry Buildings

Robert C. Mack, FAIA, and John P. Speweik

A NOTE TO OUR USERS: The web versions of the **Preservation Briefs** differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

Masonry--brick, stone, terra-cotta, and concrete block--is found on nearly every historic building. Structures with all-masonry exteriors come to mind immediately, but most other buildings at least have masonry foundations or chimneys. Although generally considered "permanent," masonry is subject to deterioration, especially at the mortar joints. Repointing, also known simply as "pointing"or--somewhat inaccurately--"tuck pointing"*, is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar. Properly done, repointing restores the visual and physical integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may also cause physical damage to the masonry units themselves.

The purpose of this Brief is to provide general guidance on appropriate materials and methods for repointing historic masonry buildings and it is intended to benefit building owners, architects, and contractors. The Brief should serve as a guide to prepare specifications for repointing historic masonry buildings. It should also help develop sensitivity to the particular needs of historic masonry, and to assist historic building owners in working cooperatively with architects, architectural conservators and historic preservation consultants, and contractors. Although specifically intended for historic buildings, the guidance is appropriate for other masonry buildings as well. This publication updates *Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings* to include all types of historic unit masonry. The scope of the earlier Brief has also been expanded to acknowledge that the many buildings constructed in the first half of the 20th century are now historic and eligible for listing in the National Register of Historic Places, and that they may have been originally constructed with portland cement mortar.

**Tuckpointing technically describes a primarily decorative application of a raised mortar joint or lime putty joint on top of flush mortar joints.*

Historical Background

Mortar consisting primarily of lime and sand has been used as an integral part of masonry structures for thousands of years. Up until about the mid-19th century, lime or quicklime (sometimes called lump lime) was delivered to construction sites, where it had to be slaked, or combined with water. Mixing with water caused it to boil and resulted in a wet lime putty that was left to mature in a pit or wooden box for several weeks, up to a year. Traditional mortar was made from lime putty, or slaked lime, combined with local sand, generally in a ratio of 1 part lime putty to 3 parts sand by volume. Often other ingredients, such as crushed marine shells (another source of lime), brick dust, clay, natural cements, pigments, and even animal hair were also added to mortar, but the basic formulation for lime putty and sand mortar remained unchanged for centuries until the advent of portland cement or its forerunner, Roman cement, a natural, hydraulic cement.

Portland cement was patented in Great Britain in 1824. It was named after the stone from Portland in Dorset which it resembled when hard. This is a fast-curing, hydraulic cement which hardens under water. Portland cement was first manufactured in the United States in 1872, although it was imported before this date. But it was not in common use throughout the country until the early 20th century. Up until the turn of the century portland cement was considered primarily an additive, or "minor ingredient" to help accelerate mortar set time. By the 1930s, however, most masons used a mix of equal parts portland cement and lime putty. Thus, the mortar found in masonry structures built between 1873 and 1930 can range from pure lime and sand mixes to a wide variety of lime, portland cement, and sand combinations.

In the 1930s more new mortar products intended to hasten and simplify masons' work were introduced in the U.S. These included **masonry cement**, a premixed, bagged mortar which is a combination of portland cement and ground limestone, and **hydrated lime**, machine-slaked lime that eliminated the necessity of slaking quicklime into putty at the site.

Identifying the Problem Before Repointing

The decision to repoint is most often related to some obvious sign of deterioration, such as disintegrating mortar, cracks in mortar joints, loose bricks or stones, damp walls, or damaged plasterwork. It is, however, erroneous to assume that repointing alone will solve deficiencies that result from other problems. The root cause of the deterioration--leaking roofs or gutters, differential settlement of the building, capillary action causing rising damp, or extreme weather exposure--should always be dealt with prior to beginning work.

Without appropriate repairs to eliminate the source of the problem, mortar deterioration will continue and any repointing will have been a waste of time and money.

Use of Consultants. Because there are so many possible causes for deterioration in historic buildings, it may be desirable to retain a consultant, such as a historic architect or architectural conservator, to analyze the building. In addition to determining the most appropriate solutions to the problems, a consultant can prepare specifications which reflect the particular requirements of each job and can provide oversight of the work in progress. Referrals to preservation consultants frequently can be obtained from State Historic Preservation Offices, the American Institute for Conservation of Historic and Artistic Works (AIC), the Association for Preservation Technology (APT), and local chapters of the American Institute of Architects (AIA).

Masons practice using lime putty mortar to repair historic marble. Photo: NPS files.

Finding an Appropriate Mortar Match

Preliminary research is necessary to ensure that the proposed repointing work is both physically and visually appropriate to the building. Analysis of unweathered portions of the historic mortar to which the new mortar will be matched can suggest appropriate mixes for the repointing mortar so that it will not damage the building because it is excessively strong or vapor impermeable.

This late 19th century granite has recently been repointed with the joint profile and mortar color carefully matched to the original. Photo: NPS files.

Examination and analysis of the masonry units--brick, stone or terra cotta--and the techniques used in the original construction will assist in maintaining the building's historic appearance. A simple, non- technical, evaluation of the masonry units and mortar can provide information concerning the relative strength and permeability of each--critical factors in selecting the repointing mortar--while a visual analysis of the historic mortar can provide the information necessary for developing the new mortar mix and application techniques.

Although not crucial to a successful repointing project, for projects involving properties of special historic significance, a mortar analysis by a qualified laboratory can be useful by providing information on the original ingredients. However, there are limitations with such an analysis, and replacement mortar specifications should not be based solely on laboratory analysis. Analysis requires interpretation, and there are important factors which affect the condition and performance of the mortar that cannot be established through laboratory analysis. These may include: the original water content, rate of curing, weather conditions during original construction, the method of mixing and placing the mortar, and the cleanliness and condition of the sand. *The most useful information that can come out of laboratory analysis is the identification of sand by gradation and color.* This allows the color and the texture of the mortar to be matched with some accuracy because sand is the largest ingredient by volume.

In creating a repointing mortar that is compatible with the masonry units, the objective is to achieve one that matches the historic mortar as closely as possible, so that the new material can coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity. The exact physical and chemical properties of the historic mortar are not of major significance as long as the new mortar conforms to the following criteria:

- The new mortar must match the historic mortar in **color, texture and tooling.** (If a laboratory analysis is undertaken, it may be possible to match the binder components and their proportions with the historic mortar, if those materials are available.)
- The **sand must match the sand** in the historic mortar. (The color and texture of the new mortar will usually fall into place if the sand is matched successfully.)
- The new mortar must have **greater vapor permeability** and be **softer** (measured in compressive strength) than the masonry units.
- The new mortar must be **as vapor permeable** and **as soft or softer** (measured in compressive strength) than the historic mortar. (Softness or hardness is not necessarily an indication of permeability; old, hard lime mortars can still retain high permeability.)

This mortar is the proper consistency for repointing historic brick. Photo: John P. Speweik.

Mortar Analysis

Methods for analyzing mortars can be divided into two broad categories: **wet chemical** and **instrumental.** Many laboratories that analyze historic mortars use a simple **wet-chemical** method called acid digestion, whereby a sample of the mortar is crushed and then mixed with a dilute acid. The acid dissolves all the carbonate-containing minerals not only in the binder, but also in the aggregate (such as oyster shells, coral sands, or other carbonate-based materials), as well as any other acid-soluble materials. The sand and fine-grained acid-insoluble material is left behind. There are several variations on the simple acid digestion test. One involves collecting the carbon dioxide gas given off as the carbonate is digested by the acid; based on the gas volume the carbnate content of the mortar can be accurately determined (Jedrzejewska, 1960). Simple acid digestion methods are rapid, inexpensive, and easy to perform, but the information they provide about the original composition of a mortar is limited to the color and texture of the sand. The gas collection method provides more information about the binder than a simple acid digestion test.

Instrumental analysis methods that have been used to evaluate mortars include polarized light or thin-section microscopy, scanning electron microscopy, atomic absorption spectroscopy, X-ray diffraction, and differential thermal analysis. All instrumental methods require not only expensive, specialized equipment, but also highly-trained experienced analysts. However, instrumental methods can provide much more information about a mortar. Thin-section microscopy is probably the most commonly used instrumental method. Examination of thin slices of a mortar in transmitted light is often used to supplement acid digestion methods, particularly to look for carbonate-based aggregate. For example, the new ASTM test method, ASTM C 1324-96 "Test Method for Examination and Analysis of Hardened Mortars" which was designed specifically for the analysis of modern lime-cement and masonry cement mortars, combines a complex series of wet chemical analyses with thin-section microscopy.

The drawback of most mortar analysis methods is that mortar samples of known composition have not been analyzed in order to evaluate the method. Historic mortars were not prepared to narrowly defined specifications from materials of uniform quality; they contain a wide array of locally derived materials combined at the discretion of the mason. While a particular method might be able to accurately determine the original proportions of a lime-cement-sand mortar prepared from modern materials, the usefulness of that method for evaluating historic mortars is questionable unless it has been tested against mortars prepared from materials more commonly used in the past. **Lorraine Schnabel.**

Properties of Mortar

Mortars for repointing should be softer or more permeable than the masonry units and no harder or more impermeable than the historic mortar to prevent damage to the masonry units. It is a common error to assume that hardness or high strength is a measure of appropriateness, particularly for lime-based historic mortars. Stresses within a wall caused by expansion, contraction, moisture migration, or settlement must be accommodated in some manner; in a masonry wall, these stresses should be relieved by the mortar rather than by the masonry units. A mortar that is stronger in compressive strength than the masonry units will not "give," thus causing stresses to be relieved through the masonry units--resulting in permanent damage to the masonry, such as cracking and spalling, that cannot be repaired easily.

While stresses can also break the bond between the mortar and the masonry units, permitting water to penetrate the resulting hairline cracks, this is easier to correct in the joint through repointing than if the break occurs in the masonry units.

Permeability, or rate of vapor transmission, is also critical. High lime mortars are more permeable than denser cement mortars. Historically, mortar acted as a bedding material--not unlike an expansion joint--rather than a "glue" for the masonry units, and moisture was able to migrate through the mortar joints rather than the masonry units. When moisture evaporates from the masonry it deposits any soluble salts either on the surface as *efflorescence* or below the surface as *subflorescence.* While salts deposited on the surface of masonry units are usually relatively harmless, salt crystallization within a masonry unit creates pressure that can cause parts ofthe outer surface to spall off or delaminate. If the mortar does not permitmoisture or moisture vapor to migrate out of the wall and evaporate, theresult will be damage to the masonry units.

This early 19th century building is being repointed with lime mortar. Photo: Travis McDonald.

Components of Mortar

Sand. Sand is the largest component of mortar and the material that gives mortar its distinctive color, texture and cohesiveness. Sand must be free of impurities, such as salts or clay. The three key characteristics of sand are: particle shape, gradation and void ratios.

When viewed under a magnifying glass or low-power microscope, particles of sand generally have either rounded edges, such as found in beach and river sand, or sharp, angular edges, found in crushed or manufactured sand. For repointing mortar, rounded or natural sand is preferred for two reasons. It is usually similar to the sand in the historic mortar and provides a better visual match. It also has better working qualities or plasticity and can thus be forced into the joint more easily, forming a good contact with the remaining historic mortar and the surface of the adjacent masonry units. Although manufactured sand is frequently more readily available, it is usually possible to locate a supply of rounded sand.

The gradation of the sand (particle size distribution) plays a very important role in the durability and cohesive properties of a mortar. Mortar must have a certain percentage of large to small particle sizes in order to deliver the optimum performance. Acceptable guidelines on particle size distribution may be found in ASTM C 144 (American Society for Testing and Materials). However, in actuality, since neither historic nor modern sands are always in compliance with ASTM C 144, matching the same particle appearance and gradation usually requires sieving the sand.

A scoop of sand contains many small voids between the individual grains. A mortar that performs well fills all these small voids with binder (cement/lime combination or mix) in a balanced manner. Well-graded sand generally has a 30 per cent void ratio by volume. Thus, 30 per cent binder by volume generally should be used, unless the historic mortar had a different binder: aggregate ratio. This represents the 1:3 binder to sand ratios often seen in mortar specifications.

For repointing, sand generally should conform to ASTM C 144 to assure proper gradation and freedom from impurities; some variation may be necessary to match the original size and gradation. Sand color and texture also should match the original as closely as possible to provide the proper color match without other additives.

Lime. Mortar formulations prior to the late-19th century used lime as the primary binding material. Lime is derived from heating limestone at high temperatures which burns off the carbon dioxide, and turns the limestone into quicklime. There are three types of limestone--calcium, magnesium, and dolomitic--differentiated by the different levels of magnesium carbonate they contain which impart specific qualities to mortar. Historically, calcium lime was used for mortar rather than the dolomitic lime (calcium magnesium carbonate) most often used today. But it is also important to keep in mind the fact that the historic limes, and other components of mortar, varied a great deal because they were natural, as opposed to modern lime which is manufactured and, therefore, standardized. Because some of the kinds of lime, as well as other components of mortar, that were used historically are no longer readily available, even when a conscious effort is made to replicate a "historic" mix, this may not be achievable due to the differences between modern and historic materials.

Caulking was inappropriately used here in place of mortar on the top of the wall. As a result, it has not been durable. Photo: NPS files.

Lime, itself, when mixed with water into a paste is very plastic and creamy. It will remain workable and soft indefinitely, if stored in a sealed container. Lime (calcium hydroxide) hardens by carbonation absorbing carbon dioxide primarily from the air, converting itself to calcium carbonate. Once a lime and sand mortar is mixed and placed in a wall, it begins the process of carbonation. If lime mortar is left to dry too rapidly, carbonation of the mortar will be reduced, resulting in poor adhesion and poor durability. In addition, lime mortar is slightly water soluble and thus is able to re-seal any hairline cracks that may develop during the life of the mortar. Lime mortar is soft, porous, and changes little in volume during temperature fluctuations thus making it a good choice for historic buildings. *Because of these qualities, high calcium lime mortar may be considered for many repointing projects, not just those involving historic buildings.*

For repointing, lime should conform to ASTM C 207, Type S, or Type SA, Hydrated Lime for Masonry Purposes. This machine-slaked lime is designed to assure high plasticity and water retention. The use of quicklime which must be slaked and soaked by hand may have advantages over hydrated lime in some restoration projects if time and money allow.

Lime putty. Lime putty is slaked lime that has a putty or paste-like consistency. It should conform to ASTM C 5. Mortar can be mixed using lime putty according to ASTM C 270 property or proportion specification.

Portland cement. More recent, 20th-century mortar has used portland cement as a primary binding material. A straight portland cement and sand mortar is extremely hard, resists the movement of water, shrinks upon setting, and undergoes relatively large thermal movements. When mixed with water, portland cement forms a harsh, stiff paste that is quite unworkable, becoming hard very quickly. (Unlike lime, portland cement will harden regardless of weather conditions and does not require wetting and drying cycles.) Some portland cement assists the workability and plasticity of the mortar without adversely affecting the finished project; it also provides early strength to the mortar and speeds setting. Thus, it may be appropriate to add some portland cement to an essentially lime-based mortar even when repointing relatively soft 18th or 19th century brick under some circumstances when a slightly harder mortar is required. The more portland cement that is added to a mortar formulation the harder it becomes--and the faster the initial set.

For repointing, portland cement should conform to ASTM C 150. White, non- staining portland cement may provide a better color match for some historic mortars than the more commonly available grey portland cement. But, it should not be assumed, however, that white portland cement is always appropriate for all historic buildings, since the original mortar may have been mixed with grey cement. The cement should not have more than 0.60 per cent alkali to help avoid efflorescence.

Masonry cement. Masonry cement is a preblended mortar mix commonly found at hardware and home repair stores. It is designed to produce mortars with a compressive strength of 750 psi or higher when mixed with sand and water at the job site. It may contain hydrated lime, but it always contains a large amount of portland cement, as well as ground limestone and other workability agents, including air-entraining agents. Because masonry cements are not required to contain hydrated lime, and generally do not contain lime, they produce high strength mortars that can damage historic masonry. *For this reason, they generally are not recommended for use on historic masonry buildings.*

Lime mortar (pre-blended). Hydrated lime mortars, and pre-blended lime putty mortars with or without a matched sand are commercially available. Custom mortars are also available with color. In most instances, pre-blended lime mortars containing sand may not provide an exact match; however, if the project calls for total repointing, a pre-blended lime mortar may be worth considering as long as the mortar is compatible in strength with the masonry. If the project involves only selected, "spot" repointing, then it may be better to carry out a mortar analysis which can provide a custom pre-blended lime mortar with a matching sand. In either case, if a preblended lime mortar is to be used, it should contain Type S or SA hydrated lime conforming to ASTM C 207.

Water. Water should be potable--clean and free from acids, alkalis, or other dissolved organic materials.

Other Components

Historic components. In addition to the color of the sand, the texture of the mortar is of critical importance in duplicating historic mortar. Most mortars dating from the mid-19th century on--with some exceptions--have a fairly homogeneous texture and color. Some earlier mortars are not as uniformly textured and may contain lumps of partially burned lime or "dirty lime", shell (which often provided a source of lime, particularly in coastal areas), natural cements, pieces of clay, lampblack or other pigments, or even animal hair. The visual characteristics of these mortars can be duplicated through the use of similar materials in the repointing mortar.

Replicating such unique or individual mortars will require writing new specifications for each project. If possible, suggested sources for special materials should be included. For example, crushed oyster shells can be obtained in a variety of sizes from poultry supply dealers.

Pigments. Some historic mortars, particularly in the late 19th century, were tinted to match or contrast with the brick or stone. Red pigments, sometimes in the form of brick dust, as well as brown, and black pigments were commonly used. Modern pigments are available which can be added to the mortar at the job site, but they should not exceed 10 per cent by weight of the portland cement in the mix, and carbon black should be limited to 2 per cent. Only synthetic mineral oxides, which are alkali-proof and sun-fast, should be used to prevent bleaching and fading.

Modern components. Admixtures are used to create specific characteristics in mortar, and whether they should be used will depend upon the individual project. *Air entraining agents*, for example, help the mortar to resist freeze-thaw damage in northern climates. *Accelerators* are used to reduce mortar freezing prior to setting while *retarders* help to extend the mortar life in hot climates. Selection of admixtures should be made by the architect or architectural conservator as part of the specifications, not something routinely added by the masons.

Generally, modern chemical additives are unnecessary and may, in fact, have detrimental effects in historic masonry projects. The use of antifreeze compounds is not recommended. They are not very effective with high lime mortars and may introduce salts, which may cause efflorescence later. A better practice is to warm the sand and water, and to protect the completed work from freezing. No definitive study has determined whether air-entraining additives should be used to resist frost action and enhance plasticity, but in areas of extreme exposure requiring high-strength mortars with lower permeability, air-entrainment of 10-16 percent may be desirable (see formula for "severe weather exposure" in **Mortar Type and Mix**). Bonding agents are not a substitute for proper joint preparation, and they should generally be avoided. If the joint is properly prepared, there will be a good bond between the new mortar and the adjacent surfaces. In addition, a bonding agent is difficult to remove if smeared on a masonry surface.

Mortar Type and Mix

Mortars for repointing projects, especially those involving historic buildings, typically are custom mixed in order to ensure the proper physical and visual qualities. These materials can be combined in varying proportions to create a mortar with the desired performance and durability. The actual specification of a particular mortar type should take into consideration all of the factors affecting the life of the building including: current site conditions, present condition of the masonry, function of the new mortar, degree of weather exposure, and skill of the mason.

Here, a hammer and chisel are being correctly used to prepare a joint for repointing. Photo: John P. Speweik.

Thus, no two repointing projects are exactly the same. Modern materials specified for use in repointing mortar should conform to specifications of the American Society for Testing and Materials (ASTM) or comparable federal specifications, and the resulting mortar should conform to ASTM C 270, Mortar for Unit Masonry.

Specifying the proportions for the repointing mortar for a specific job is not as difficult as it might seem. Five mortar types, each with a corresponding recommended mix, have been established by ASTM to distinguish high strength mortar from soft flexible mortars. The ASTM designated them in decreasing order of approximate general strength as Type M (2,500 psi), Type S (1,800 psi), Type N (750 psi), Type O (350 psi) and Type K (75 psi). (The letters identifying the types are from the words MASON WORK using every other letter.) Type K has the highest lime content of the mixes that contain portland cement, although it is seldom used today, except for some historic preservation projects. The designation "L" in the accompanying chart identifies a straight lime and sand mix. Specifying the appropriate ASTM mortar by proportion of ingredients, will ensure the desired physical properties. Unless specified otherwise, measurements or proportions for mortar mixes are always given in the following order: cement-lime-sand. Thus, a Type K mix, for example, would be referred to as 1-3-10, or 1 part cement to 3 parts lime to 10 parts sand. Other requirements to create the desired visual qualities should be included in the specifications.

The strength of a mortar can vary. If mixed with higher amounts of portland cement, a harder mortar is obtained. The more lime that is added, the softer and more plastic the mortar becomes, increasing its workability. A mortar strong in compressive strength might be desirable for a hard stone (such as granite) pier holding up a bridge deck, whereas a softer, more permeable lime mortar would be preferable for a historic wall of soft brick. Masonry deterioration caused by salt deposition results when the mortar is less permeable than the masonry unit. A strong mortar is still more permeable than hard, dense stone. However, in a wall constructed of soft bricks where the masonry unit itself has a relatively high permeability or vapor transmission rate, a soft, high lime mortar is necessary to retain sufficient permeability.

Budgeting and Scheduling

Repointing is both expensive and time consuming due to the extent of handwork and special materials required. It is preferable to repoint only those areas that require work rather than an entire wall, as is often specified. But, if 25 to 50 per cent or more of a wall needs to be repointed, repointing the entire wall may be more cost effective than spot repointing.

Total repointing may also be more sensible when access is difficult, requiring the erection of expensive scaffolding (unless the majority of the mortar is sound and unlikely to require replacement in the foreseeable future). Each project requires judgement based on a variety of factors. Recognizing this at the outset will help to prevent many jobs from becoming prohibitively expensive.

When repairing this stone wall, the mason matched the raised profile of the original tuckpointing. Photo: NPS files.

In scheduling, seasonal aspects need to be considered first. Generally speaking, wall temperatures between 40 and 95 degrees F (8 and 38 degrees C) will prevent freezing or excessive evaporation of the water in the mortar. Ideally, repointing should be done in shade, away from strong sunlight in order to slow the drying process, especially during hot weather. If necessary, shade can be provided for large-scale projects with appropriate modifications to scaffolding.

The relationship of repointing to other work proposed on the building must also be recognized. For example, if paint removal or cleaning is anticipated, and if the mortar joints are basically sound and need only selective repointing, it is generally better to postpone repointing until after completion of these activities. However, if the mortar has eroded badly, allowing moisture to penetrate deeply into the wall, repointing should be accomplished before cleaning. Related work, such as structural or roof repairs, should be scheduled so that they do not interfere with repointing and so that all work can take maximum advantage of erected scaffolding.

Building managers also must recognize the difficulties that a repointing project can create.

A mechanical grinder improperly used to cut out the horizontal joint and incompatible repointing have seriously damaged the 19th century brick. Photo: NPS files.

The process is time consuming, and scaffolding may need to remain in place for an extended period of time. The joint preparation process can be quite noisy and can generate large quantities of dust which must be controlled, especially at air intakes to protect human health, and also where it might damage operating machinery. Entrances may be blocked from time to time making access difficult for both building tenants and visitors. Clearly, building managers will need to coordinate the repointing work with other events at the site.

Contractor Selection

The ideal way to select a contractor is to ask knowledgeable owners of recently repointed historic buildings for recommendations. Qualified contractors then can provide lists of other repointing projects for inspection. More commonly, however, the contractor for a repointing project is selected through a competitive bidding process over which the client or consultant has only limited control. In this situation it is important to ensure that the specifications stipulate that masons must have a minimum of five years' experience with repointing historic masonry buildings to be eligible to bid on the project. Contracts are awarded to the lowest responsible bidder, and bidders who have performed poorly on other projects usually can be eliminated from consideration on this basis, even if they have the lowest prices.

The contract documents should call for unit prices as well as a base bid. Unit pricing forces the contractor to determine in advance what the cost addition or reduction will be for work which varies from the scope of the base bid. If, for example, the contractor has fifty linear feet less of stone repointing than indicated on the contract documents but thirty linear feet more of brick repointing, it will be easy to determine the final price for the work. Note that each type of work--brick repointing, stone repointing, or similar items--will have its own unit price. The unit price also should reflect quantities; one linear foot of pointing in five different spots will be more expensive than five contiguous linear feet.

Execution of the Work

Test Panels. These panels are prepared by the contractor using the same techniques that will be used on the remainder of the project. Several panel locations--preferably not on the front or other highly visible location of the building--may be necessary to include all types of masonry, joint styles, mortar colors, and other problems likely to be encountered on the job.

If cleaning tests, for example, are also to be undertaken, they should be carried out in the same location. Usually a 3 foot by 3 foot area is sufficient for brickwork, while a somewhat larger area may be required for stonework. These panels establish an acceptable standard of work and serve as a benchmark for evaluating and accepting subsequent work on the building.

Unskilled repointing has negatively impacted the character of this late-19th century building. Photo: NPS files.

Joint Preparation. Old mortar should be removed to a minimum depth of 2 to 2-1/2 times the width of the joint to ensure an adequate bond and to prevent mortar "popouts." For most brick joints, this will require removal of the mortar to a depth of approximately ½ to 1 inch; for stone masonry with wide joints, mortar may need to be removed to a depth of several inches. Any loose or disintegrated mortar beyond this minimum depth also should be removed.

Although some damage may be inevitable, careful joint preparation can help limit damage to masonry units. The traditional manner of removing old mortar is through the use of hand chisels and mash hammers. Though labor-intensive, in most instances this method poses the least threat for damage to historic masonry units and produces the best final product.

The most common method of removing mortar, however, is through the use of power saws or grinders. The use of power tools by unskilled masons can be disastrous for historic masonry, particularly soft brick. Using power saws on walls with thin joints, such as most brick walls, almost always will result in damage to the masonry units by breaking the edges and by overcutting on the head, or vertical joints.

However, small pneumatically-powered chisels generally can be used safely and effectively to remove mortar on historic buildings as long as the masons maintain appropriate control over the equipment. Under certain circumstances, thin diamond-bladed grinders may be used to cut out *horizontal* joints only on hard portland cement mortar common to most early-20th century masonry buildings. Usually, automatic tools most

successfully remove old mortar without damaging the masonry units when they are used in combination with hand tools in preparation for repointing. Where horizontal joints are uniform and fairly wide, it may be possible to use a power masonry saw to assist the removal of mortar, such as by cutting along the middle of the joint; final mortar removal from the sides of the joints still should be done with a hand chisel and hammer. Caulking cutters with diamond blades can sometimes be used successfully to cut out joints without damaging the masonry. Caulking cutters are slow; they do not rotate, but vibrate at very high speeds, thus minimizing the possibility of damage to masonry units. Although mechanical tools may be safely used in limited circumstances to cut out horizontal joints in preparation for repointing, they should never be used on vertical joints because of the danger of slipping and cutting into the brick above or below the vertical joint. Using power tools to remove mortar without damaging the surrounding masonry units also necessitates highly skilled masons experienced in working on historic masonry buildings. Contractors should demonstrate proficiency with power tools before their use is approved.

Using any of these power tools may also be more acceptable on hard stone, such as quartzite or granite, than on terra cotta with its glass-like glaze, or on soft brick or stone. The test panel should determine the acceptability of power tools. If power tools are to be permitted, the contractor should establish a quality control program to account for worker fatigue and similar variables.

Mortar should be removed cleanly from the masonry units, leaving square corners at the back of the cut. Before filling, the joints should be rinsed with a jet of water to remove all loose particles and dust. At the time of filling, the joints should be damp, but with no standing water present. For masonry walls--limestone, sandstone and common brick--that are extremely absorbent, it is recommended that a continual mist of water be applied for a few hours before repointing begins.

Mortar Preparation. Mortar components should be measured and mixed carefully to assure the uniformity of visual and physical characteristics. Dry ingredients are measured by volume and thoroughly mixed before the addition of any water. Sand must be added in a damp, loose condition to avoid over sanding. Repointing mortar is typically pre-hydrated by adding water so it will just hold together, thus allowing it to stand for a period of time before the final water is added. Half the water should be added, followed by mixing for approximately 5 minutes. The remaining water should then be added in small portions until a mortar of the desired consistency is reached. The total volume of water necessary may vary from batch to batch, depending on weather conditions. It is important to keep the water to a minimum for two reasons: first, a drier mortar is cleaner to work with, and it can be compacted tightly into the joints; second, with no excess water to evaporate, the mortar cures without shrinkage cracks. Mortar should be used within approximately 30 minutes of final mixing, and "retempering," or adding more water, should not be permitted.

Using Lime Putty to Make Mortar. Mortar made with lime putty and sand, sometimes referred to as roughage or course stuff, should be measured by volume, and may require slightly different proportions from those used with hydrated lime. No additional water is usually needed to achieve a workable consistency because enough water is already contained in the putty. Sand is proportioned first, followed by the lime putty, then mixed for five minutes or until all the sand is thoroughly coated with the lime putty. But mixing, in the familiar sense of turning over with a hoe, sometimes may not be sufficient if the best possible performance is to be obtained from a lime putty mortar. Although the old practice of chopping, beating and ramming the mortar has largely been forgotten, recent field work has confirmed that lime putty and sand rammed and beaten with a wooden mallet or ax handle, interspersed by chopping with a hoe, can significantly improve workability and performance. The intensity of this action increases the overall lime/sand contact and removes any surplus water by compacting the other ingredients. It may also be advantageous for larger projects to use a mortar pan mill for mixing. Mortar pan mills which have a long tradition in Europe produce a superior lime putty mortar not attainable with today's modern paddle and drum type mixers.

For larger repointing projects the lime putty and sand can be mixed together ahead of time and stored indefinitely, on or off site, which eliminates the need for piles of sand on the job site. This mixture, which resembles damp brown sugar, must be protected from the air in sealed containers with a wet piece of burlap over the top or sealed in a large plastic bag to prevent evaporation and premature carbonation. The lime putty and sand mixture can be recombined into a workable plastic state months later with no additional water.

If portland cement is specified in a lime putty and sand mortar--Type O (1:2:9) or Type K (1:3:11)--the portland cement should first be mixed into a slurry paste before adding it to the lime putty and sand. Not only will this ensure that the portland cement is evenly distributed throughout the mixture, but if dry portland cement is added to wet ingredients it tends to "ball up," jeopardizing dispersion. (Usually water must be added to the lime putty and sand anyway once the portland cement is introduced.) Any color pigments should be added at this stage and mixed for a full five minutes. The mortar should be used within 30 minutes to 1½ hours and it should not be retempered. Once portland cement has been added the mortar can no longer be stored.

Filling the Joint. Where existing mortar has been removed to a depth of greater than 1 inch, these deeper areas should be filled first, compacting the new mortar in several layers. The back of the entire joint should be filled successively by applying approximately 1/4 inch of mortar, packing it well into the back corners. This

application may extend along the wall for several feet. As soon as the mortar has reached thumb-print hardness, another 1/4 inch layer of mortar--approximately the same thickness--may be applied. Several layers will be needed to fill the joint flush with the outer surface of the masonry. It is important to allow each layer time to harden before the next layer is applied; most of the mortar shrinkage occurs during the hardening process and layering thus minimizes overall shrinkage.

When the final layer of mortar is thumb-print hard, the joint should be tooled to match the historic joint. Proper timing of the tooling is important for uniform color and appearance. If tooled when too soft, the color will be lighter than expected, and hairline cracks may occur; if tooled when too hard, there may be dark streaks called "tool burning," and good closure of the mortar against the masonry units will not be achieved.

If the old bricks or stones have worn, rounded edges, it is best to recess the final mortar slightly from the face of the masonry. This treatment will help avoid a joint which is visually wider than the actual joint; it also will avoid creation of a large, thin featheredge which is easily damaged, thus admitting water. After tooling, excess mortar can be removed from the edge of the joint by brushing with a natural bristle or nylon brush. Metal bristle brushes should never be used on historic masonry.

Curing Conditions. The preliminary hardening of high-lime content mortars--those mortars that contain more lime by volume than portland cement, i.e., Type O (1:2:9), Type K (1:3:11), and straight lime/sand, Type "L" (0:1:3)--takes place fairly rapidly as water in the mix is lost to the porous surface of the masonry and through evaporation. A high lime mortar (especially Type "L") left to dry out too rapidly can result in chalking, poor adhesion, and poor durability. Periodic wetting of the repointed area after the mortar joints are thumb-print hard and have been finish tooled may significantly accelerate the carbonation process. When feasible, misting using a hand sprayer with a fine nozzle can be simple to do for a day or two after repointing. Local conditions will dictate the frequency of wetting, but initially it may be as often as every hour and gradually reduced to every three or four hours. Walls should be covered with burlap for the first three days after repointing. (Plastic may be used, but it should be tented out and not placed directly against the wall.) This helps keep the walls damp and protects them from direct sunlight. Once carbonation of the lime has begun, it will continue for many years and the lime will gain strength as it reverts back to calcium carbonate within the wall.

Aging **the Mortar.** Even with the best efforts at matching the existing mortar color, texture, and materials, there will usually be a visible difference between the old and new work, partly because the new mortar has been matched to the unweathered portions of the historic mortar. Another reason for a slight mismatch may be that the sand is more exposed in old mortar due to the slight erosion of the lime or cement. Although spot repointing is generally preferable and some color difference should be acceptable, if the difference between old and new mortar is too extreme, it may be advisable in some instances to repoint an entire area of a wall, or an entire feature such as a bay, to minimize the difference between the old and the new mortar. If the mortars have been properly matched, usually the best way to deal with surface color differences is to let the mortars age naturally. Other treatments to overcome these differences, including cleaning the non-repointed areas or staining the new mortar, should be carefully tested prior to implementation.

This 18th century pediment and surrounding wall exhibit distinctively different mortar joints. Photo: NPS files.

Staining the new mortar to achieve a better color match is generally not recommended, but it may be appropriate in some instances. Although staining may provide an initial match, the old and new mortars may weather at different rates, leading to visual differences after a few seasons. In addition, the mixtures used to stain the mortar may be harmful to the masonry; for example, they may introduce salts into the masonry which can lead to efflorescence.

Cleaning the Repointed Masonry. If repointing work is carefully executed, there will be little need for cleaning other than to remove the small amount of mortar from the edge of the joint following tooling. This can be done with a stiff natural bristle or nylon brush after the mortar has dried, but before it is initially set (1-2 hours). Mortar that has hardened can usually be removed with a wooden paddle or, if necessary, a chisel.

Further cleaning is best accomplished with plain water and natural bristle or nylon brushes. If chemicals must be used, they should be selected with extreme caution. Improper cleaning can lead to deterioration of the masonry units, deterioration of the mortar, mortar smear, and efflorescence. New mortar joints are especially susceptible to damage because they do not become fully cured for several months. Chemical cleaners, particularly acids, should never be used on dry masonry. The masonry should always be completely soaked once with water before chemicals are applied. After cleaning, the walls should be flushed again with plain water to remove all traces of the chemicals.

Several precautions should be taken if a freshly repointed masonry wall is to be cleaned. First, the mortar should be fully hardened before cleaning. Thirty days is usually sufficient, depending on weather and exposure; as mentioned previously, the mortar will continue to cure even after it has hardened. Test panels should be prepared to evaluate the effects of different cleaning methods. Generally, on newly repointed masonry walls, only very low pressure (100 psi) water washing supplemented by stiff natural bristle or nylon brushes should be used, except on glazed or polished surfaces, where only soft cloths should be used.**

New construction "bloom" or efflorescence occasionally appears within the first few months of repointing and usually disappears through the normal process of weathering. If the efflorescence is not removed by natural processes, the safest way to remove it is by dry brushing with stiff natural or nylon bristle brushes followed by wet brushing. Hydrochloric (muriatic) acid, is generally ineffective, and it should not be used to remove efflorescence. It may liberate additional salts, which, in turn, can lead to more efflorescence.

Surface Grouting is sometimes suggested as an alternative to repointing brick buildings, in particular. This process involves the application of a thin coat of cement-based grout to the mortar joints and the mortar/brick interface. To be effective, the grout must extend slightly onto the face of the masonry units, thus widening the joint visually. The change in the joint appearance can alter the historic character of the structure to an unacceptable degree. In addition, although masking of the bricks is intended to keep the grout off the remainder of the face of the bricks, some level of residue, called "veiling," will inevitably remain. Surface grouting cannot substitute for the more extensive work of repointing, and it is not a recommended treatment for historic masonry.

***Additional information on masonry cleaning is presented in Preservation Briefs 1: Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings, Robert C. Mack, FAIA, and Anne Grimmer, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 2000; and Keeping it Clean: Removing Exterior Dirt, Paint, Stains & Graffiti from Historic Masonry Buildings, Anne E. Grimmer, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 1988.*

Visually Examining the Mortar and the Masonry Units

A simple *in situ* comparison will help determine the hardness and condition of the mortar and the masonry units. Begin by scraping the mortar with a screwdriver, and gradually tapping harder with a cold chisel and mason's hammer. Masonry units can be tested in the same way beginning, even more gently, by scraping with a fingernail. This relative analysis which is derived from the 10-point hardness scale used to describe minerals, provides a good starting point for selection of an appropriate mortar. It is described more fully in "The Russack System for Brick & Mortar Description" referenced in **Selected Reading** at the end of this Brief.

Mortar samples should be chosen carefully, and picked from a variety of locations on the building to find unweathered mortar, if possible. Portions of the building may have been repointed in the past while other areas may be subject to conditions causing unusual deterioration. There may be several colors of mortar dating from different construction periods or sand used from different sources during the initial construction. Any of these situations can give false readings to the visual or physical characteristics required for the new mortar. Variations should be noted which may require developing more than one mix.

1) Remove with a chisel and hammer three or four unweathered samples of the mortar to be matched from several locations on the building. (Set the largest sample aside--this will be used later for comparison with the repointing mortar). Removing a full representation of samples will allow selection of a "mean" or average mortar sample.

2) Mash the remaining samples with a wooden mallet, or hammer if necessary, until they are separated into their constituent parts. There should be a good handful of the material.

3) Examine the powdered portion--the lime and/or cement matrix of the mortar. Most particularly, note the color. There is a tendency to think of historic mortars as having white binders, but grey portland cement was available by the last quarter of the 19th century, and traditional limes were also sometimes grey. Thus, in some instances, the natural color of the historic binder may be grey, rather than white. The mortar may also have been tinted to create a colored mortar, and this color should be identified at this point.

4) Carefully blow away the powdery material (the lime and/or cement matrix which bound the mortar together).

5) With a low power (10 power) magnifying glass, examine the remaining sand and other materials such as

lumps of lime or shell.

6) Note and record the wide range of color as well as the varying sizes of the individual grains of sand, impurities, or other materials.

Other Factors to Consider

Color. Regardless of the color of the binder or colored additives, the sand is the primary material that gives mortar its color. A surprising variety of colors of sand may be found in a single sample of historic mortar, and the different sizes of the grains of sand or other materials, such as incompletely ground lime or cement, play an important role in the texture of the repointing mortar. Therefore, when specifying sand for repointing mortar, it may be necessary to obtain sand from several sources and to combine or screen them in order to approximate the range of sand colors and grain sizes in the historic mortar sample.

Pointing Style. Close examination of the historic masonry wall and the techniques used in the original construction will assist in maintaining the visual qualities of the building. Pointing styles and the methods of producing them should be examined. It is important to look at both the horizontal and the vertical joints to determine the order in which they were tooled and whether they were the same style. Some late-19th and early-20th century buildings, for example, have horizontal joints that were raked back while the vertical joints were finished flush and stained to match the bricks, thus creating the illusion of horizontal bands. Pointing styles may also differ from one facade to another; front walls often received greater attention to mortar detailing than side and rear walls. **Tuckpointing** is not true repointing but the application of a raised joint or lime putty joint on top of flush mortar joints. **Penciling** is a purely decorative, painted surface treatment over a mortar joint, often in a contrasting color.

Masonry Units. The masonry units should also be examined so that any replacement units will match the historic masonry. Within a wall there may be a wide range of colors, textures, and sizes, particularly with hand-made brick or rough-cut, locally-quarried stone. Replacement units should blend in with the full range of masonry units rather than a single brick or stone.

Matching Color and Texture of the Repointing Mortar

New mortar should match the unweathered interior portions of the historic mortar. The simplest way to check the match is to make a small sample of the proposed mix and allow it to cure at a temperature of approximately 70 degrees F for about a week, or it can be baked in an oven to speed up the curing; this sample is then broken open and the surface is compared with the surface of the largest "saved" sample of historic mortar.

If a proper color match cannot be achieved through the use of natural sand or colored aggregates like crushed marble or brick dust, it may be necessary to use a modern mortar pigment.

During the early stages of the project, it should be determined how closely the new mortar should match the historic mortar. Will "quite close" be sufficient, or is "exactly" expected? The specifications should state this clearly so that the contractor has a reasonable idea how much time and expense will be required to develop an acceptable match.

The same judgment will be necessary in matching replacement terra cotta, stone or brick. If there is a known source for replacements, this should be included in the specifications. If a source cannot be determined prior to the bidding process, the specifications should include an estimated price for the replacement materials with the final price based on the actual cost to the contractor.

Mortar Types
(Measured by volume)

Designation	Cement	Hydrated Lime or Lime Putty	Sand
M	1	1/4	3 - 3 3/4
S	1	1/2	4 - 4 1/2
N	1	1	5 - 6
O	1	2	8 - 9
K	1	3	10 - 12
"L"	0	1	2 1/4 - 3

Suggested Mortar Types for Different Exposures			
	Exposure		
Masonry Material	Sheltered	Moderate	Severe
Very durable: granite, hard-cored brick, etc.	O	N	S
Moderately durable: limestone, durable stone, molded brick	K	O	N
Minimally durable: soft hand-made brick	"L"	K	O

Summary

For the Owner/Administrator. The owner or administrator of a historic building should remember that repointing is likely to be a lengthy and expensive process. First, there must be adequate time for evaluation of the building and investigation into the cause of problems. Then, there will be time needed for preparation of the contract documents. The work itself is precise, time-consuming and noisy, and scaffolding may cover the face of the building for some time. Therefore, the owner must carefully plan the work to avoid problems. Schedules for both repointing and other activities will thus require careful coordination to avoid unanticipated conflicts. The owner must avoid the tendency to rush the work or cut corners if the historic building is to retain its visual integrity and the job is to be durable.

For the Architect/Consultant. Because the primary role of the consultant is to ensure the life of the building, a knowledge of historic construction techniques and the special problems found in older buildings is essential. The consultant must assist the owner in planning for logistical problems relating to research and construction. It is the consultant's responsibility to determine the cause of the mortar deterioration and ensure that it is corrected before the masonry is repointed. The consultant must also be prepared to spend more time in project inspections than is customary in modern construction.

For the Masons. Successful repointing depends on the masons themselves. Experienced masons understand the special requirements for work on historic buildings and the added time and expense they require. The entire masonry crew must be willing and able to perform the work in conformance with the specifications, even when the specifications may not be in conformance with standard practice. At the same time, the masons should not hesitate to question the specifications if it appears that the work specified would damage the building.

Conclusion

A good repointing job is meant to last, at least 30 years, and preferably 50- 100 years. Shortcuts and poor craftsmanship result not only in diminishing the historic character of a building, but also in a job that looks bad, and will require future repointing sooner than if the work had been done correctly. The mortar joint in a historic masonry building has often been called a wall's "first line of defense." Good repointing practices guarantee the long life of the mortar joint, the wall, and the historic structure. Although careful maintenance will help preserve the freshly repointed mortar joints, it is important to remember that mortar joints are intended to be sacrificial and will probably require repointing some time in the future. Nevertheless, if the historic mortar joints proved durable for many years, then careful repointing should have an equally long life, ultimately contributing to the preservation of the entire building.

Selected Reading

Ashurst, John & Nicola. *Practical Building Conservation. Vol. 3: Mortars, Plasters and Renders.* New York: Halsted Press, a Division of John Wiley & Sons, Inc., 1988.

Cliver, E. Blaine. "Tests for the Analysis of Mortar Samples." *Bulletin of the Association for Preservation Technology.* Vol. 6, No. 1 (1974), pp. 68-73.

Coney, William B., AIA. *Masonry Repointing of Twentieth-Century Buildings.* Illinois Preservation Series. Number 10. Springfield, IL: Division of Preservation Services, Illinois Historic Preservation Agency, 1989.

Davidson, J.I. "Masonry Mortar." *Canadian Building Digest.* CBD 163. Ottawa, ONT: Division of Building

Research, National Research Council of Canada, 1974.

Ferro, Maximillian L., AIA, RIBA. "The Russack System for Brick and Mortar Description: A Field Method for Assessing Masonry Hardness." *Technology and Conservation.* Vol. 5, No. 2 (Summer 1980), pp. 32-35.

Hooker, Kenneth A. "Field Notes on Repointing." *Aberdeen's Magazine of Masonry Construction.* Vol. 4, No. 8 (August 1991), pp. 326-328.

Jedrzejewska, H. "Old Mortars in Poland: A New Method of Investigation." Studies in Conservation. Vol. 5, No. 4 (1960), pp. 132-138.

"Lime's Role in Mortar." Aberdeen's Magazine of Masonry Construction. Vol. 9, No. 8 (August 1996), pp. 364-368.

Phillips, Morgan W. "Brief Notes on the Subjects of Analyzing Paints and Mortars and the Recording of Moulding Profiles: The Trouble with Paint and Mortar Analysis." *Bulletin of the Association for Preservation Technology.* Vol. 10, No. 2 (1978), pp. 77-89.

Preparation and Use of Lime Mortars: An Introduction to the Principles of Using Lime Mortars. Scottish Lime Centre for Historic Scotland. Edinburgh: Historic Scotland, 1995.

Schierhorn, Carolyn. "Ensuring Mortar Color Consistency." *Aberdeen's Magazine of Masonry Construction.* Vol. 9, No. 1 (January 1996), pp. 33-35.

"Should Air-Entrained Mortars Be Used?" *Aberdeen's Magazine of Masonry Construction.* Vol. 7, No. 9 (September 1994), pp. 419-422.

Sickels-Taves, Lauren B. "Creep, Shrinkage, and Mortars in Historic Preservation." *Journal of Testing and Evaluation, JTEVA.* Vol. 23, No. 6 (November 1995), pp. 447-452.

Speweik, John P. *The History of Masonry Mortar in America*, 1720-1995. Arlington, VA: National Lime Association, 1995.

Speweik, John P. "Repointing Right: Why Using Modern Mortar Can Damage a Historic House." *Old-House Journal.* Vol. XXV, No. 4 (July-August 1997), pp. 46-51.

Technical Notes on Brick Construction. Brick Institute of America, Reston, VA.

"Moisture Resistance of Brick Masonry: Maintenance." 7F. February 1986.

"Mortars for Brick Masonry." 8 Revised II. November 1989.

"Standard Specification for Portland Cement-Lime Mortar for Brick Masonry." 8A Revised. September 1988.

"Mortar for Brick Masonry-Selection and Controls." 8B Reissued. September 1988. (July/August 1976).

"Guide Specifications for Brick Masonry, Part V Mortar and Grout." 11E Revised. September 1991.

"Bonds and Patterns in Brickwork." 30 Reissued. September 1988.

Useful Addresses

Brick Institute of America
11490 Commerce Park Drive
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National Lime Association
200 N. Glebe Road, Suite 800
Arlington, VA 22203

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077

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Home page logo: Soft mortar for repointing. Photo: John P. Speweik.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

Questions

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Technical Preservation Services
National Park Service
U.S. Department of the Interior

Rehabilitating Interiors in Historic Buildings
Identifying and Preserving Character-Defining Elements

H. Ward Jandl

A NOTE TO OUR USERS: The web versions of the **Preservation Briefs** differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

A floor plan, the arrangement of spaces, and features and applied finishes may be individually or collectively important in defining the historic character of the building and the purpose for which it was constructed. Thus, their identification, retention, protection, and repair should be given prime consideration in every preservation project. Caution should be exercised in developing plans that would radically change character-defining spaces or that would obscure, damage or destroy interior features or finishes.

The interiors of mills and industrial buildings are frequently open, unadorned spaces with exposed structural elements. While these spaces can serve many new uses, the floor to ceiling height and exposed truss system are character-defining features that should be retained in rehabilitation. Photo: NPS files.

While the exterior of a building may be its most prominent visible aspect, or its "public face," its interior can be even more important in conveying the building's history and development over time. Rehabilitation within the context of the Secretary of the Interior's Standards for Rehabilitation calls for the preservation of exterior and interior portions or features of the building that are significant to its historic, architectural and cultural values.

Interior components worthy of preservation may include the building's plan (sequence of spaces and circulation patterns), the building's spaces (rooms and volumes), individual architectural features, and the various finishes and materials that make up the walls, floors, and ceilings. A theater auditorium or sequences of rooms such as double parlors or a lobby leading to a stairway that ascends to a mezzanine may comprise a building's most important spaces. Individual rooms may contain notable features such as plaster cornices, millwork, parquet wood floors, and hardware. Paints, wall coverings, and finishing techniques such as

graining, may provide color, texture, and patterns which add to a building's unique character.

Virtually all rehabilitations of historic buildings involve some degree of interior alteration, even if the buildings are to be used for their original purpose. Interior rehabilitation proposals may range from preservation of existing features and spaces to total reconfigurations. In some cases, depending on the building, restoration may be warranted to preserve historic character adequately; in other cases, extensive alterations may be perfectly acceptable.

This Preservation Brief has been developed to assist building owners and architects in identifying and evaluating those elements of a building's interior that contribute to its historic character and in planning for the preservation of those elements in the process of rehabilitation. The guidance applies to all building types and styles, from 18th century churches to 20th century office buildings. The Brief does not attempt to provide specific advice on preservation techniques and treatments, given the vast range of buildings, but rather suggests general preservation approaches to guide construction work.

Not only are the features of this early 20th century interior worthy of preservation, the planned sequence of spaces impart a grandeur that is characteristic of high style residences of the period. Photo: Jack E. Boucher, HABS collection.

Identifying and Evaluating the Importance of Interior Elements Prior to Rehabilitation

Before determining what uses might be appropriate and before drawing up plans, a thorough professional assessment should be undertaken to identify those tangible architectural components that, prior to rehabilitation, convey the building's sense of time and place--that is, its "historic character." Such an assessment, accomplished by walking through and taking account of each element that makes up the interior, can help ensure that a truly compatible use for the building, one that requires minimal alteration to the building, is selected.

Researching The Building's History

A review of the building's history will reveal why and when the building achieved significance or how it contributes to the significance of the district. This information helps to evaluate whether a particular rehabilitation treatment will be appropriate to the building and whether it will preserve those tangible components of the building that convey its significance for association with specific events or persons along with its architectural importance. In this regard, National Register files may prove useful in explaining why and for what period of time the building is significant. In some cases research may show that later alterations are significant to the building; in other cases, the alterations may be without historical or architectural merit, and may be removed in the rehabilitation.

Identifying Interior Elements

Interiors of buildings can be seen as a series of primary and secondary spaces. The goal of the assessment is to identify which elements contribute to the building's character and which do not. Sometimes it will be the sequence and flow of spaces, and not just the individual rooms themselves, that contribute to the building's character. This is particularly evident in buildings that have strong central axes or those that are consciously

Many institutional buildings possess distinctive spaces or floor plans that are important in conveying the significance of the property. This grand hall, which occupies the entire floor of the building, could not be subdivided without destroying the integrity of the space. Photo: NPS files.

asymmetrical in design. In other cases, it may be the size or shape of the space that is distinctive.

The importance of some interiors may not be readily apparent based on a visual inspection; sometimes rooms that do not appear to be architecturally distinguished are associated with important persons and events that occurred within the building.

Primary spaces, are found in all buildings, both monumental and modest. Examples may include foyers, corridors, elevator lobbies, assembly rooms, stairhalls, and parlors. Often they are the places in the building that the public uses and sees; sometimes they are the most architecturally detailed spaces in the building, carefully proportioned and finished with costly materials. They may be functionally and architecturally related to the building's external appearance. In a simpler building, a primary space may be distinguishable only by its location, size, proportions, or use. Primary spaces are always important to the character of the building and should be preserved.

Secondary spaces are generally more utilitarian in appearance and size than primary spaces. They may include areas and rooms that service the building, such as bathrooms, and kitchens. Examples of secondary spaces in a commercial or office structure may include storerooms, service corridors, and in some cases, the offices themselves. Secondary spaces tend to be of less importance to the building and may accept greater change in the course of work without compromising the building's historic character.

The interior of this 19th worker's house has not been properly maintained, but it may be as important historically as a richly ornamented interior. Its wide baseboards, flat window trim, and four-panel door should be carefully preserved in a rehabilitation project. Photo: NPS files.

Spaces are often designed to interrelate both visually and functionally. The sequence of spaces, such as vestibule-hall-parlor or foyer-lobby-stair-auditorium or stairhall-corridor-classroom, can define and express the building's historic function and unique character. Important sequences of spaces should be identified and retained in the rehabilitation project.

Floor plans may also be distinctive and characteristic of a style of architecture or a region. Examples include Greek Revival and shotgun houses. Floor plans may also reflect social, educational, and medical theories of the period. Many 19th century psychiatric institutions, for example, had plans based on the ideas of Thomas Kirkbride, a Philadelphia doctor who authored a book on asylum design.

In addition to evaluating the relative importance of the various spaces, the assessment should identify architectural features and finishes that are part of the interior's history and character. Marble or wood wainscoting in corridors, elevator cabs, crown molding, baseboards, mantels, ceiling medallions, window and door trim, tile and parquet floors, and staircases are among those features that can be found in historic buildings. Architectural finishes of note may include grained woodwork, marbleized columns, and plastered walls. Those features that are characteristic of the building's style and period of construction should, again, be retained in the rehabilitation.

Features and finishes, even if machine-made and not exhibiting particularly fine craftsmanship, may be character defining; these would include pressed metal ceilings and millwork around windows and doors. The interior of a plain, simple detailed worker's house of the 19th century may be as important historically as a richly ornamented, high-style townhouse of the same period. Both resources, if equally intact, convey important information about the early inhabitants and deserve the same careful attention to detail in the preservation process.

The location and condition of the building's existing heating, plumbing, and electrical systems also need to be noted in the assessment. The visible features of historic systems--radiators, grilles, light fixtures, switchplates, bathtubs, etc.--can contribute to the overall character of the building, even if the systems themselves need upgrading.

Assessing Alterations and Deterioration

In assessing a building's interior, it is important to ascertain the extent of alteration and deterioration that may have taken place over the years; these factors help determine what degree of change is appropriate in the project. Close examination of existing fabric and original floorplans, where available, can reveal which alterations have been additive, such as new partitions inserted for functional or structural reasons and historic features covered up rather than destroyed. It can also reveal which have been subtractive, such as key walls removed and architectural features destroyed. If an interior has been modified by additive changes and if these changes have not acquired significance, it may be relatively easy to remove the alterations and return the interior to its historic appearance. If an interior has been greatly altered through subtractive changes, there may be more latitude in making further alterations in the process of rehabilitation because the integrity of the interior has been compromised. At the same time, if the interior had been exceptionally significant, and solid documentation on its historic condition is available, reconstruction of the missing features may be the preferred option.

This corridor has glazed walls, oak trim, and marble wainscotting, typical of those found in the late 19th and early 20th century office buildings. Corridors such as this, displaying simple detailing, should be a priority in rehabilitation projects involving commercial buildings. Photo: NPS files.

It is always a recommended practice to photograph interior spaces and features thoroughly prior to rehabilitation. Measured floor plans showing the existing conditions are extremely useful. This documentation is invaluable in drawing up rehabilitation plans and specifications and in assessing the impact of changes to the property for historic preservation certification purposes.

Drawing Up Plans and Executing Work

If the historic building is to be rehabilitated, it is critical that the new use not require substantial alteration of distinctive spaces or removal of character-defining architectural features or finishes. If an interior loses the physical vestiges of its past as well as its historic function, the sense of time and place associated both with the building and the district in which it is located is lost.

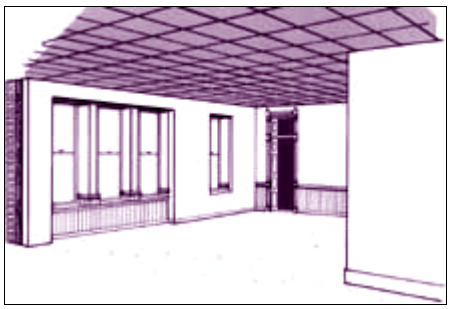
The recommended approaches that follow address common problems associated with the rehabilitation of historic interiors and have been adapted from the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings. Adherence to these suggestions can help ensure that character-defining interior elements are preserved in the process of rehabilitation. The checklist covers a range of situations and is not intended to be all-inclusive. Readers are strongly encouraged to review the full set of guidelines before undertaking any rehabilitation project.

Recommended Approaches for Rehabilitating Historic Interiors

1. Retain and preserve floor plans and interior spaces that are important in defining the overall historic character of the building. This includes the size, configuration, proportion, and relationship of rooms and corridors; the relationship of features to spaces; and the spaces themselves such as lobbies, reception halls, entrance halls, double parlors, theaters, auditoriums, and important industrial or commercial use spaces. Put service functions required by the building's new use, such as bathrooms, mechanical equipment, and office machines, in secondary spaces.

2. Avoid subdividing spaces that are characteristic of a building type or style or that are directly associated with specific persons or patterns of events. Space may be subdivided both vertically through the insertion of new partitions or horizontally through insertion of new floors or mezzanines. The insertion of new additional floors should be considered only when they will not damage or destroy the structural system or obscure, damage, or destroy character-defining spaces, features, or finishes. If rooms have already been subdivided through an earlier insensitive renovation, consider removing the partitions and restoring the room to its original proportions and size.

3. Avoid making new cuts in floors and ceilings where such cuts would change character-defining spaces and the historic configuration of such spaces. Inserting of a new atrium or a lightwell is appropriate only in very limited situations where the existing interiors are not historically or architecturally distinguished.



Furring out exterior walls to add insulation and suspending new ceilings to hide ductwork can change a room's proportions and cause interior features to appear fragmented. The interior character of this school classroom that was converted to apartment use has been destroyed. Drawing: Neal A. Vogel

4. Avoid installing dropped ceilings below ornamental ceilings or in rooms where high ceilings are part of the building's character. In addition to obscuring or destroying significant details, such treatments will also change the space's proportions. If dropped ceilings are installed in buildings that lack character-defining spaces, such as mills and factories, they should be well set back from the windows so they are not visible from the exterior.

5. Retain and preserve interior features and finishes that are important in defining the overall historic character of the building. This might include columns, doors, cornices, baseboards, fireplaces and mantels, paneling, light fixtures, elevator cabs, hardware, and flooring; and wallpaper, plaster, paint, and finishes such as stenciling, marbleizing, and graining; and other decorative materials that accent interior features and provide color, texture, and patterning to walls, floors, and ceilings.

6. Retain stairs in their historic configuration and to location. If a second means of egress is required, consider constructing new stairs in secondary spaces. The application of fire-retardant coatings, such as intumescent paints; the installation of fire suppression systems, such as sprinklers; and the construction of glass enclosures can in many cases permit retention of stairs and other character-defining features.

7. Retain and preserve visible features of early mechanical systems that are important in defining the overall historic character of the building, such as radiators, vents, fans, grilles, plumbing fixtures, switchplates, and lights. If new heating, air conditioning, lighting and plumbing systems are installed, they should be done in a way that does not destroy character-defining spaces, features and finishes. Ducts, pipes, and wiring should be installed as inconspicuously as possible: in secondary spaces, in the attic or basement if possible, or in closets.

8. Avoid "furring out" perimeter walls for insulation purposes. This requires unnecessary removal of window trim and can change a room's proportions. Consider alternative means of improving thermal performance, such as installing insulation in attics and basements and adding storm windows.

9. Avoid removing paint and plaster from traditionally finished surfaces, to expose masonry and wood. Conversely, avoid painting previously unpainted millwork. Repairing deteriorated plasterwork is encouraged. If the plaster is too deteriorated to save, and the walls and ceilings are not highly ornamented, gypsum board may be an acceptable replacement material. The use of paint colors appropriate to the period of the building's construction is encouraged.

Plaster has been removed from perimeter walls, leaving brick exposed. The plaster should have been retained and repaired, as necessary. Photo: NPS files.

10. Avoid using destructive methods--propane and butane torches or sandblasting--to remove paint or other coatings from historic features. Avoid harsh cleaning agents that can change the appearance of wood.

Meeting Building, Life Safety and Fire Codes

Buildings undergoing rehabilitation must comply with existing building, life safety and fire codes. The application of codes to specific projects varies from building to building, and town to town. Code requirements may make some reuse proposals impractical; in other cases, only minor changes may be needed to bring the project into compliance. In some situations, it may be possible to obtain a code variance to preserve distinctive interior features. (It should be noted that the Secretary's Standards for Rehabilitation take precedence over other regulations and codes in determining whether a rehabilitation project qualifies for Federal tax benefits.) A thorough understanding of the applicable regulations and close coordination with code officials, building inspectors, and fire marshals can prevent the alteration of significant historic interiors.

Sources of Assistance

Rehabilitation and restoration work should be undertaken by professionals who have an established reputation in the field.

Given the wide range of interior work items, from ornamental plaster repair to marble cleaning and the application of graining, it is possible that a number of specialists and subcontractors will need to be brought in to bring the project to completion. State Historic Preservation Officers and local preservation organizations may be a useful source of information in this regard. Good sources of information on appropriate preservation techniques for specific interior features and finishes include the Bulletin of the Association for Preservation Technology and The Old-House Journal; other useful publications are listed in the bibliography.

Protecting Interior Elements During Rehabilitation

Architectural features and finishes to be preserved in the process of rehabilitation should be clearly marked on plans and at the site. This step, along with careful supervision of the interior demolition work and protection against arson and vandalism, can prevent the unintended destruction of architectural elements that contribute to the building's historic character.

Protective coverings should be installed around architectural features and finishes to avoid damage in the course of construction work and to protect workers. Staircases and floors, in particular, are subjected to dirt and heavy wear, and the risk exists of incurring costly or irreparable damage. In most cases, the best, and least costly, preservation approach is to design and construct a protective system that enables stairs and floors to be used yet protects them from damage. Other architectural features such as mantels, doors, wainscoting, and decorative finishes may be protected by using heavy canvas or plastic sheets.

Summary

In many cases, the interior of a historic building is as important as its exterior. The careful identification and evaluation of interior architectural elements, after undertaking research on the building's history and use, is critically important before changes to the building are contemplated. Only after this evaluation should new uses be decided and plans be drawn up. The best rehabilitation is one that preserves and protects those rooms, sequences of spaces, features and finishes that define and shape the overall historic character of the building.

After rehabilitation, this severly deteriorated space was returned to its original elegance. Plaster was repaired and repainted; scagliola colums were restored to match marble; and missing decorative metalwork was re-installed in front of the windows. Photo: Carol M. Highsmith.

Selected Reading List

There are few books written exclusively on preserving historic interiors, and most of these tend to focus on residential interiors. Articles on the subject appear regularly in The Old-House Journal, the Bulletin of the Association for Preservation Technology, and Historic Preservation Magazine.

Ferro, Maximilian L., and Melissa L. Cook. *Electric Wiring and Lighting in Historic American Buildings.* New Bedford, Massachusetts: AFC/A Nortek Company, 1984.

Fisher, Charles E. "Temporary Protection of Historic Stairways During Rehabilitation Work." *Preservation Tech Note*. Washington, D.C.: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, 1985.

Jennings, Jan, and Herbert Gottfried. *American Vernacular Interior Architecture 1870-1940.* New York: Van Nostrand Reinhold Company, 1988.

Johnson, Ed. *Old House Woodwork Restoration: How to Restore Doors, Windows, Walls, Stairs and Decorative Trim to Their Original Beauty.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983.

Labine, Clem, and Carolyn Flaherty (editors). *The Old-House Journal Compendium.* Woodstock, New York: The Overlook Press, 1980.

The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings. Washington, D.C.: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, rev. 1983.

U.S. Department of Housing and Urban Development. *Rehabilitation Guidelines, volume 111*. Washington, D.C.: U.S. Department of Housing and Urban Development, 1980-84.

Winkler, Gail Caskey, and Roger W. Moss. *Victorian Interior Decoration: American Interiors 1830-1900*. New York: Henry Holt and Company, 1986.

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Washington, D.C. October, 1988

Home page logo: Detail of carving on interior shutter. Hammond-Harwood House, Annapolis, Maryland. Photo: NPS files.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

Questions

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Painting Historic Interiors

Sara B. Chase

A NOTE TO OUR USERS: The web versions of the **Preservation Briefs** differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

The paint Americans used in the past is undeniably part of a technological and commercial record. But beyond that, the colors we have chosen and continue to select for our interior living and working spaces--bright and exuberant, purposefully somber, or a combination of hues--reflect our nation's cultural influences and our individual and collective spirit. Paint color is a simple, direct expression of the time, and of taste, values, and mood. To consider paint only as a protective coating is to misunderstand its meaning as an important aspect of America's heritage.

Researching the interior paint history is the key to a successful preservation or restoration project. The decorative detailing can be appreciated in this Puerto Rico Theater primarily because of appropriate paint color and paint placement. Photo: Max Toro.

This Brief is about historic interior paints and choosing new paints for historic interiors if repainting is necessary or desirable. It addresses a variety of materials and features: plaster walls and ceilings; wooden doors, molding, and trim; and metal items such as radiators and railings. It provides background information about some of the types of paint which were used in the past, discusses the more common causes and effects of interior paint failure, and explains the principal factors guiding decisions about repainting, including what level of paint investigation may be appropriate. Careful thought should be given to each interior paint project, depending on the history of the building and its painted surfaces. Treatments may range from protecting extant decorative surfaces, to ordering custommade paint that replicates the original paint color, to using today's paint straight off the shelf and out of the can.

Finally, stripping old paints or applying new oil/alkyd paints poses serious health and safety concerns; the State Historic Preservation Officer should be contacted for current legal and technical information on removal, disposal, and health and safety precautions.

Constituents of Historic Paint: Pigment, Binder, and Vehicle

Paint is a dispersion of small solid particles, usually crystalline, in a liquid medium. Applied to a surface, this liquid has the special quality of becoming a solid, protective film when it dries. Paint also enhances the appearance of surfaces. A late Victorian writer observed that the coming of a painter to a house was cause for celebration. Indeed, these statements not only indicate the chemical and physical complexity of paint, but also its emotional impact.

Pigment. Pigment made the paint opaque, thus preventing deterioration of the substrate caused by ultraviolet light, and added color, thus making the paint attractive. White lead, a whitish corrosion product of lead, was most often used to provide opacity. The white pigment in a colored paint is often called the "hiding" pigment. In addition to preventing the sun's damaging rays from hitting the surface of the substrate, the white lead also helped prevent the growth of mold and mildew. Not until early in the 20th century was a successful substitute, titanium dioxide (TiO2), patented, and even then, it did not come into prevalent use by itself until the mid-20th century (earlier in the century, titanium oxide and white lead were often mixed). Zinc oxide was used briefly as a hiding pigment after 1850.

There were numerous companies producing white lead in the United States by mid-19th century. Shown is one manufacturer's flyer. Photo: NPS files.

Early tinting pigments for house paints consisted of the earth pigments--ochres, siennas, umbers made from iron-oxide containing clay--and a few synthesized colorants such as Prussian blue, or mercuric sulfide (crimson). From the early 1800s on more pigments were developed and used to offer a wider and brighter variety of hues.

Binder. The most common binder in interior paints was, and still is, oil. Chalk was sometimes added to waterbased paints to help bind the pigment particles together. Other common binders included hide glue and gelatin.

Vehicle. The fluid component was termed the vehicle, or medium, because it carried the pigment. Historically, vehicles included turpentine in oil paints and water in waterbased paints, but other vehicles were sometimes used, such as milk in casein paints.

Oil-Based and Water-Based Paints

The two major types of paint are termed oil-based and water-based. For oilbased paints, linseed oil was frequently chosen because it is a drying oil. When thinned with an organic solvent such as turpentine for easier spreading, its drying speed was enhanced. To make the drying even faster, drying agents such as cobalt compounds were frequently added. Because the addition of driers was most successfully done in hot or boiling oil, boiled linseed oil was preferable. The drying rate of linseed oil paints was relatively rapid at first, for several days immediately after application, and paint soon felt dry to the touch; it is important to remember, however, that linseed oil paint continues to dry--or more precisely, to crosslink--over decades and thus continues to a point of brittleness as the paint ages. Strong and durable with a surface sheen, oil-based paints were mainly used for

wood trim and metal.

Whitewashes and distemper paints differed from oil paints in appearance primarily because the vehicle was water. Waterbased paints were always flat, having no gloss of their own. Because the paint film dried to the touch as soon as the water evaporated, driers were not needed. Waterbase paints were fairly strong, with the pigments well bound as in hide glue distempers, but they did not hold up to abrasion. Wood trim, therefore, was rarely painted with these types of paint historically, though interior plaster surfaces were frequently coated with whitewash and calcimine. Distemper paints were commonly used for decorative work.

Recent Changes to Paint Constituents. Until the mid-20th century, almost all paints used in America could be divided according to the type of binder each had. Chemists sought to improve paints, especially when the two world wars made traditional paint components scarce and expensive. Modern paints are far more complex chemically and physically than early paints. More ingredients have been added to the simple threepart system of pigment, binder, and vehicle. Fillers or extenders such as clay and chalk were put in to make oil paints flow better and to make them cheaper as well. Mildewcides and fungicides were prevalent and popular until their environmental hazards were seen to outweigh their benefits. New formulations which retard the growth of the mildew and fungi are being used. As noted, lead was eliminated after 1950. Most recently, volatile organic solvents in oil paint and thinners have been categorized as environmentally hazardous.

A major difference in modern paints is the change in binder from the use of natural boiled linseed oil to an alkyd oil which is generally derived from soybean or safflower oil. Use of synthetic resins, such as acrylics and epoxies, has become prevalent in paint manufacture in the last 30 years or so. Acrylic resin emulsions in latex paints, with water thinners, have also become common.

Types of Historic Paints

Historic paints were often made with what was available, rather than adhering to strict formulas. Recipes for successful formulas can be found in historic documents, such as newspapers, illustrating the combinations of ingredients which could be used to produce a paint.

Oil-based paints: Linseed oil, a volatile thinner such as turpentine; a hiding pigment (usually white lead) and coloring pigments.

Enamels: natural resin varnish was added to oil-based paint to provide a hard, more glossy surface.

Glaze: a translucent layer applied to protect the paint and to impart a more uniform gloss surface. Usually made from linseed oil with natural resin varnish added. Some glazes have small quantities of tinting pigments such as verdigris or Prussian blue; some had no pigments added.

Water-based paints: Water, pigment, and a binder, such as hide glue, other natural glues, or gums. Usually used on interior plaster surfaces.

Whitewash: often used on interior plaster surfaces in utilitarian spaces and, at times, used on interior beams; consisted of water, slaked lime, salt, and a variety of other materials. Occasionally a pigment (usually an ochre or other earth pigment) was added to provide tint or color.

Distemper: used for interior applications, were made from water, glues (one or more different natural glues, gelatine, and gums) with whiting as the basic white pigment to which other tinting pigments were added.

Calcimine, or kalsomine: often used on interior surfaces and is another common name for distemper.

Tempera: paint prepared with pigment, egg yolk or white and water; used almost exclusively for decorative treatments.

Gouache: a waterbased paint made of whiting, pigment, water, and gum arabic as the binder; used almost exclusively for decorative treatments.

Milk-based paint:

Casein: also called milk paint, was made with hydrated (slaked) lime, pigment, and milk. Most often oil was added, making a strong emulsion paint. Various recipes call for a large variety of additives to increase durability. Casein paints were also used for exterior surfaces.

Pre-1875 Paints

Production and Appearance. How were paints made prior to the widespread use of factory-made paint after 1875? How did they look? The answers to these questions are provided more to underscore the differences between early paints and today's paints than for practical purposes. Duplicating the composition and appearance of historic paints, including the unevenness of color, the irregularity of surface texture, the depth provided by a glaze top coat, and the directional lines of application, can be extremely challenging to a contemporary painter who is using modern materials.

The Boston Stone (1737), a surviving relic of early paint production, was used for pigment grinding in the shop of Thomas Child of Boston, a London-trained painter and stainer. Photo: Courtesy, SPNEA.

The pigments used in early paints were coarsely and unevenly ground, and they were dispersed in the paint medium by hand; thus, there is a subtle unevenness of color across the surface of many pre-1875 paints. The dry pigments had to be ground in oil to form a paste and the paste had to be successively thinned with more oil and turpentine before the paint was ready for application. The thickness of the oil medium produced the shiny surface desired in the 18th century. In combination with the cylindrical (or round) shaped brushes with wood handles and boar bristles, it also produced a paint film with a surface texture of brush strokes.

Geographical Variation. The early churches and missions built by the French in Canada and the Spanish in the southwestern United States often had painted decoration on whitewashed plaster walls, done with early waterbased paints. By the mid-17th century oil paint was applied to wood trim in many New England houses, and whitewash was applied to walls. These two types of paint, one capable of highly decorative effects such as imitating marble or expensive wood and the other cheap to make and relatively easy to apply, brightened and enhanced American interiors. In cities such as Boston, Philadelphia, New York, and later, Washington, painters and stainers who were trained guildsmen from England practiced their craft and instructed apprentices. The painter's palette of colors included black and white and grays, buffs and tans, ochre yellows and iron oxide reds, and greens (from copper compounds) as well as Prussian blue. That such painting was valued and that a glossy appearance on wood was important are substantiated by evidence of clear and tinted glazes which may be found by microscopic examination.

Brush Marks. Early paints did not dry out to a flat level surface. Leveling, in fact, was a

property of paint that was much sought after later, but until well into the 19th century, oil paints and whitewashes showed the signs of brush marks. Application therefore was a matter of stroking the brush in the right direction for the best appearance. The rule of thumb was to draw the brush in its final stokes in the direction of the grain of the wood. Raisedfield paneling, then, required that the painter first cover the surface with paint and afterward draw the brush carefully along the vertical areas from bottom to top and along the top and bottom bevels of the panel horizontally from one side to the other.

In the 19th and early 20th centuries, for very fine finishes, several coats were applied with each coat being rubbed down with rotten stone or pumice after drying. A four to five coat application was typical; however nine coats were not uncommon at the end of the century for finishes in some of the grand mansions. Generally, they were given a final glaze finish. Though expensive, this type of finish would last for decades and give a rich, smooth appearance.

Color. Color matching is complicated by the fact that all early paints were made by hand. Each batch of paint, made by painters using books of paint "recipes" or using their own experience and instincts, might well have slight variations in color--a little darker or lighter, a little bluer and so on. The earliest known book of paint formulations by an American painter is the 1812 guide by Hezekiah Reynolds. It gives instructions for the relative quantities of tinting pigments to be added to a base, but even with proportions held constant, the amount of mixing, or dispersion, varied from workman to workman and resulted in color variations.

Knowing all of the facts about early paints can aid in microscopic paint study. For example, finding very finely and evenly ground pigments, equally dispersed throughout the ground or vehicle, is an immediate clue that the paint was not made by hand but, rather, in a factory.

By the first decades of the 19th century more synthetic pigments were available--chrome yellow, chrome green, and shades of red. Discoveries of light, bright, clear colors in the plaster and mosaic decoration of dwellings at Pompeii caught the fancy of many Americans and came together with the technology of paint to make for a new palette of choice, with more delicacy than many of the somewhat greyeddown colors of the 18th century. Of course, the blues which could be produced with Prussian blue in the 18th and 19th centuries were originally often strong in hue. That pigment--as were a number of others--is fugitive, that is, it faded fairly quickly and thus softened in appearance. It should be remembered that high style houses from the mid-17th to late 19th centuries often had wallpaper rather than paint on the walls of the important rooms and hallways.

Glossy/Flat. Another paint innovation of the early 19th century was the use of flatter oil paints achieved by adding more turpentine to the oil, which thus both thinned and flatted them. By the 1830s the velvety look of flat paint was popular.

Wherever decorative plaster was present, as it frequently was during the height of the Federal period, distemper paints were the coating of choice. Being both thin and readily removable with hot water, they permitted the delicate plaster moldings and elaborate floral or botanical elements to be protected and tinted but not obscured by the buildup of many paint layers. (The use of waterbased paints on ceilings continued through the Victorian years for the same reasons.)

Unfortunately, flat paints attract dirt, which is less likely to adhere to high gloss surfaces, and are thus harder to wash. Victorians tended to use high gloss clear (or tinted) finishes such as varnish or shellac on much of their wood trim and to use flat or oil paints on walls and ceilings.

Decorative Painting. In interiors, paint could be used creatively and imaginatively, most often to decorate rather than to protect. Decorative forms included stencilling, graining and marbleizing, and trompe l'oeil. Stencilling. Stencilled designs on walls were often used

in the first half of the 19th century in place of wallpaper. Old Sturbridge Village, in Massachusetts, has paintings showing the interiors of a (c. 1815-1820) farmhouse which has both stencilled walls--imitating wallpaper--and painted floors or oiled and painted floor cloths, imitating fine carpets. By 1850 and for the next 60 years thereafter, stencilled and freehandpainted decoration for walls and ceilings became a high as well as a humble art. Owen Jones' *Grammar of Ornament*, published in 1859, provided the source for painted decoration from Portland to Peoria, Savannah to San Francisco.

The task of preserving or restoring decorative work, such as the complex stencilling shown here, should only be undertaken by professionals who have specialized training. Photo: Alexis Elza.

Historic doors may have graining patterns or clear finishes under one or several coats of plain paint, such as these restored 18th and 19th century doors. Photo: Jack E. Boucher, HABS, NPS.

Graining and marbleizing. If floors, walls, and ceilings were decorated by paint in a variety of styles, the wood and stone trim of rooms was not omitted. The use of faux bois, that is, painting a plain or common wood such as pine to look like mahogany or some finer wood, or faux marbre, painting a wood or plaster surface to look like marble--realistically or fantastically--was common in larger homes of the 18th century. By the early 19th century, both stylized graining and marbleizing adorned the simple rural or small town houses as well. Often baseboards and stair risers were marbleized as were fireplace surrounds. Plain slate was painted to look like fine Italian marble. In many simple buildings, and, later, in the Victorian period, many prominent buildings such as town halls and churches, the wood trim was given a realistic graining to resemble quarter sawn oak, walnut, or a host of other exotic woods.

Trompe L'oeil. Churches, courthouses, and state capitols frequently received yet another remarkable use of paint: trompe l'oeil decoration. Applied by skilled artists and artisans, painted designs--most often using distemper paints or oils--could replicate threedimensional architectural detailing such as ornate molded plaster moldings, medallions, panels, and more.

Factory-Made Paints after 1875

An enormous growth of the paint industry began in the 1860s, stimulated by the invention of a suitable marketing container--the paint can. The first factory-made paints in cans consisted of more finely ground pigments in an oil base; after purchase, additional oil was added to the contents of the can to make up the paint. Such paints saved the time of handgrinding pigments, and were discussed at length by John Masury in his numerous books. After 1875, factory-made paints were available at a reasonable cost and, as a result, greater numbers of people painted and decorated more of their buildings, and more frequently. The new commercial market created by ready-mixed paint became the cornerstone of our modern paint industry.

20th Century Paints

By the early decades of the 20th century, popular taste turned away from exuberant colors and decoration. Until the late 1920s both the Colonial Revival and Arts and Crafts styles tended toward more subdued colors and, in the case of Colonial Revival, a more limited palette. The use of *faux* finishes, however, continued. Residential architecture often featured stencilling, such as painted borders above wainscoting or at ceiling and wall edges to imitate decorative wallpaper. Institutional buildings in both cities and small towns used

wood graining on metalclad doors, door and window frames, and staircases, and had stencilled ceilings as well. Many high style public buildings of the 1920s had painted ceilings which imitated the Spanish and Italian late medieval and Renaissance styles.

Although stenciling, gilding, and faux finishes can be found, they did not express the modern style of the time. On the other hand, glaze treatments were often used in the early 20th century to "antique" walls and trim that had been painted with neutral colors, especially in Spanish Colonial Revival and Mission architecture. The glazes were applied by ragging, sponging, and other techniques which gave an interesting and uneven surface appearance. Colored plasters were sometimes used, and air brushing employed to give a craftsman-like appearance to walls, trim, and ceilings. During the same period, Williamsburg paint colors were produced and sold to people who wanted their houses to have a "historic Georgian look." Churches, country clubs, and many private buildings adopted the Williamsburg style from the late '20s onward.

The Art Deco style lobby foyer of the Paramount Theater in Sacramento, California (1931) features painted plaster columns and cornices which have been finished in gold and silver leaf. Photo: Gabriel Moulin Studios.

Often decorated with simple molded plaster designs of the Art Deco and Art Moderne styles, interiors of the 1930s and 1940s were frequently accented with metal flake paints in a full range of metallic colors, from copper to bronze. And enamels, deep but subdued hues, became popular. Paint technology had progressed and varying degrees of gloss were also available, including the mid-range enamels, variously called satin, semigloss, or eggshell. In contrast to Victorian paint treatments, this period was characterized by simplicity. To some extent, the Bauhaus aesthetic influenced taste in the 1950s; interior paints were frequently chosen from a palette limited to a few "earth" colors and a "nearly neutral" palette of off-whites and pale greys.

While the trend in colors and decorative treatments was defined by its simplicity, paint chemists were developing paints of increasing complexity. Experimentation had started early in the 20th century and accelerated greatly after World War II. Of greatest significance was the manufacture of the latex paints for consumer use. Synthetic resin emulsions carried in water offered advantages over the traditional oil paints, and even over the oil/alkyd paints: they did not yellow; they permitted water cleanup until dried; and they emitted no toxic or hazardous fumes from solvent evaporation.

Paint Investigation

Understanding each project's historic preservation goal and knowing what level of information needs to be collected to achieve that goal is an important responsibility of the purchaser of the service. Before someone is hired, the owner or manager needs to decide if a thorough investigation of painted surfaces is actually needed, and *how* to use the results when one is done.

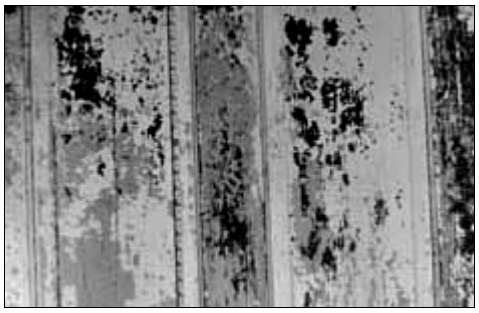
Specialists with both training and field experience conduct paint investigations. These experts use sophisticated instruments and procedures such as field sampling, cross-section analysis, and fluorescent and chemical staining to learn about the components and behaviors of historic paints. In addition, they utilize written documentation, verbal research, and visual information about past painting in the building in conjunction with findings in the field.

Paint investigation can make several contributions to a project. A complete analysis of the paint layers on surfaces within a structure can tell a great deal about the sequence of

This conservator is shown collecting paint samples onsite. Then, in a laboratory, an ultra violet light microscope will be used to identify pigment and binding media. Photo: Courtesy, Matt Mosca.

alterations that have occurred within a building, as well as potentially providing ranges of dates for some of these changes. By establishing a full sequence of paint layers (termed a chromochronology), together with other research, alterations of various building spaces and features can be associated with specific paint layers. It is by establishing this association that the correct layer is identified; when the correct layer has been identified, the color may be matched.

In addition to its archeological value, paint analysis can determine the types and colors of paint on a given surface (identification of thin glazes, decorative paint schemes, binders and pigments). Beyond color identification, then, paint analysis is also recommended to diagnose causes of paint failure. Knowing a paint binder can often explain causes as well as guide appropriate preservation or conservation treatments.



A dark layer can be seen beneath the flaking paint on these raised field panels. Depending on the project work goal and the period of the building's history being interpreted, any one of the paint layers could be duplicated in repainting. Photo: NPS files.

Owners and managers should identify all of these needs before deciding on the extent of analysis. For example, a complete paint investigation is usually recommended as part of an historic structure report. For buildings with little documentation, additions and alterations can often be identified, and possibly dated, through analysis. Often the use of such seemingly expensive techniques can save money in the long run when determining the history of building change.

It is possible to do some analysis on site; this is a much simpler process that can be undertaken for less cost than the complex laboratory procedures described above. However, the usefulness of onsite analysis is limited and the results will not be as precise as results from samples that are analyzed in a laboratory with a good microscope. Any shortcut approaches to paint analysis that do not follow scientific procedures are generally not worth the expense. In summary, if preservation and restoration treatments are being undertaken, a complete investigation is recommended; for a rehabilitation project, onsite analysis and color matching may provide an adequate palette.

Choosing a Treatment

Most projects involve repainting. It is the historic appearance of the interior and the visual impression that will be created by new paint treatments that must be considered before choosing a particular course of action. The type and colors of paint obviously depend on the type of building and the use and interpretation of its interior spaces. A consistent approach is best.

Preservation. When the treatment goal is preservation, a building's existing historic features and finishes are maintained and repaired, saving as much of the historic paint as possible. Sometimes, cleaning and washing of painted surfaces is all that is needed. Or a coating may be applied to protect important examples of history or art. If repainting is

required, the new paint is matched to existing paint colors using the safer, modern formulations. Recreating earlier surface colors and treatments is not an objective.

Interior spaces that are being rehabilitated for a new use can benefit from being repainted in historic period colors rather than a neutral off-white. Photo: NPS files.

Rehabilitation. In a typical rehabilitation, more latitude exists in choosing both the kind of new paint as well as color because the goal is the efficient reuse of interior spaces. Decisions about new paint often weigh factors such as economy and durability--use of a high quality standard paint from a local or national company and application by a qualified contractor. Color choices may be based on paint research reports prepared for interior rooms of comparable date and style. More often, though, current color values and taste are taken into account. Again, the safer paint formulations are used.

Interiors of institutional buildings, such as university buildings, city halls, libraries, and churches often contain rich decorative detailing. During rehabilitation, careful choices should be made to retain or restore selected portions of the decorative work as well as match some of the earlier colors to evoke the historic sense of time and place. At the least, it is important to use periodtypical paint color and paint placement.

Restoration. In a restoration project, the goal is to depict the property as it appeared during its period of greatest significance. This may or may not be the time of its original construction. For example, if a building dated from 1900 but historians deemed its significance to be the 1920s, the appropriate paint color match would be the 1920s layer, not the original 1900 layer.

Based on historical research, onsite collection of paint samples, and laboratory analysis, surface colors and treatments can be recreated to reflect the property at a particular period of time. It should be noted that scholarly findings may yield a color scheme that is not suited to the taste of the contemporary owner, but is nonetheless historically accurate. In restoration, personal taste in color is not at issue; the evidence should be strictly followed.

In the restoration process, colors are custom-matched by professionals to give an accurate representation. If an artist or artisan can be found, the historically replicated paint may be applied using techniques appropriate to the period of the restoration. Although custom paint manufacture is seldom undertaken, color and glazing are capable of being customized. In some projects, paint may be custom-made using linseed oil and, if building code variances allow it, white lead. For example, the repainting of a number of rooms at Mount Vernon demonstrates that it is possible to replicate historic paints and applications in all aspects; however, as noted, replication of historic paint formulation is not practical for the majority of projects.

Identifying Deteriorated and Damaged Paint Surfaces

Because painted surfaces are subject to abrasion, soiling, water damage, sunlight, and application of incompatible paints they generally need to be repainted or at least reglazed appropriately from time to time.

Abrasion. From the baseboards up to a level of about six feet off the floor, wood trim is constantly subjected to wear from being touched and inadvertently kicked, and from having furniture pushed against it. Chair rails were in fact intended to take the wear of having chairs pushed back against them instead of against the more delicate plaster wall or expensive wallpaper. Doors in particular, sometimes beautifully grained, receive extensive handling. Baseboards get scraped by various cleaning devices, and the lower rails of windows, as well as window seats, take abuse. The paint in all of these areas tends

to become abraded. Two things are important to bear in mind about areas of abraded paint. Samples taken to determine original paint colors and layer sequences will not be accurate except at undamaged edges. Also, dirt and oil or grease need to be removed before applying any new paint because new paint will not adhere to dirty, greasy surfaces.

Dirt. Soiling is another problem of interior paint. Fireplaces smoked; early coalfired furnaces put out oily black soot; gas lights and candles left dark smudges. Sometimes the dirt got deposited on plaster walls or ceilings in a way that makes the pattern of the lath behind the plaster quite clear. Another source of dirt was polluted outside air, from factories or other industries, infiltrating houses and other nearby buildings. Until smokestacks became very high, most air pollution was caused by nearby sources.

In paint investigation, dirt on the surface of paint layers; as seen under the microscope, can be very useful in suggesting the length of time a given paint layer remained exposed, and in distinguishing a finish layer from a prime or undercoat layer. This kind of soiling can happen on any painted surface in a room, but may be slightly heavier in the recesses of moldings and on upwardfacing horizontal edges. Using dirt as a sole measure, however, may be misleading if the surfaces have been cleaned. The fracture or bonding between paint layers is often used by professionals as a better means of indicating time differences between layers as well as indicating those layers that are part of a single decoration or painting.

Water. Water, the usual source of deterioration for many kinds of material, is also a prime cause of interior paint failure. As a liquid, it can come from roof leaks, from faulty plumbing or steam heating systems, or from firesuppression systems that have misfired. As a vapor, it may come from such human activities as breathing, showering, or cooking. Plaster walls sealed with unpigmented hideglue are notably susceptible to water damage because it forms a watersoluble layer between the plaster and the paint. This can cause the paint to lose adhesion when even small amounts of moisture come into contact with the watersoluble sealer.

Age/Sunlight. Finally, in historic interiors, especially where there is heavy paint buildup, paint can weaken and fail due to chemical or mechanical reasons. For example, the older linseed oil is, the more brittle it is. It also darkens when it is covered and gets no ultraviolet exposure. In rooms where there is more sunlight on one area than on others, the oil or even oil/alkyd paint will get discernibly darker in the less exposed areas in as short a time as six months. Painted over, the oil medium in older paints gets quite yellowbrown, thus changing the color of the paint. Prussian blue is one of the tinting pigments that is particularly vulnerable to fading.

Incompatible Paints. Understanding some basic differences in the strength of various paints helps to explain certain paint problems. Paints that dry to a stronger film are incompatible with those which are weaker. Acrylic latex paints are stronger than oil/alkyd paints. Oil or oil/alkyd paint is stronger than waterbased paint such as calcimine. When a stronger paint is applied over a weaker paint, it will tend to pull off any weaker paint which may have begun to lose its bond with its substrate. Thus, on many ceilings of older buildings where oil/alkyd paints have been applied over old calcimine, large strips of paint may be peeling.

Oil or varnish glazes over older paints become brittle with age, and can make removal of later paints rather easy. Sometimes it is possible to take advantage of this characteristic to reveal an earlier decorative treatment such as graining or marbleizing. Getting under the edge of the glaze with a scalpel blade can make the removal of later paints relatively simple, and relatively harmless to the fancier paint treatment. Sometimes, paints separate from each other simply due to poor surface preparation in the past or the hardening of the earlier surface paint. Use of alkaline paint strippers can cause paint to lose adhesion. When insufficiently neutralized, they leave salts in wood which cause oil or oil/alkyd paints to fail to adhere to the surface. If dirt or oily residues are not cleaned from the surfaces to be

painted, new paint will not remain well adhered.

Surface Preparation

First, it is important to note that the earlier, linseed oil-based paints were penetrating type paints, forming a bond by absorption into the substrate. Often these thin oil coatings were slightly tinted with an ironoxide pigment so coverage could be seen; the next coating applied would adhere to this first oil layer. Modern paints, on the other hand, are primarily bonding paints with little ability to penetrate a substrate. For this reason, surface preparation is extremely important for today's paints.

Before preparing the interior for repainting, all moisture penetration from failing roofs or gutters or from faulty plumbing or interior heating elements should be identified and corrected. A paint job is only as good as the preparation that goes before it. The surface to be painted, old or new, wood, plaster, masonry, or metal must be made sound and capable of taking the paint to be applied.

Scraping and Sanding. The first step in preparing interior wood and plaster surfaces which are coherent and sound is to remove any loose paint (see Paint Hazards sidebar). Careful hand scraping is always advisable for historic surfaces. Use of mechanical sanders usually leaves traces of the sander's edges, visible through the new paint film. Hand sanding is also necessary to feather the edges of the firmly adhering layers down to the bare areas so that shadow lines are avoided. Preparing previously painted interior masonry for new paint is basically similar to preparing plaster. Metals elements, such as radiators, valences, or firebacks are somewhat different. In order to get a sound paint job on metal items, the work is primarily that of sanding to remove any rust before repainting. If the existing paint is well adhered over the entire metal surface, then it may be necessary only to sand lightly to roughen the existing paint, thus providing some "tooth" for the primer and new paint layer. On wood, garnet sanding papers work well. Aluminum oxide and silicon carbide sandpapers are effective on other surfaces as well as wood; emery papers should be used on metals.

Paint Removal. When should surfaces be completely stripped? Obviously, new paint is wasted when applied on old paint which is loose, that is, extensively damaged and deteriorated. Sometimes paint on an architectural feature needs to be removed if it obscures delicate detailing. For the most part, however, if the surface is intact--and the presence of lead paint has been shown to present no health dangers to building occupants--the existing paint can be overpainted.

Well-adhered, intact paint layers (in at least one area of each room) should be covered with a sturdy protective tape, then painted over with the new paint and left in place to inform future research. The next owner may be interested in the building's past history, and methods of gleaning information from old paints grow more sophisticated all the time.

Heat/Scraping. Propane torches should never be used because they can damage historic wood features. Also, charred areas of wood will not hold the new paint. Use of a heat gun or heat plate may be relatively fast, but has both health and safety drawbacks. Heat oxidizes lead paint, causing poisonous fumes. And old walls may contain fine debris which acts like tinder and smolders when heated, bursting into flame hours after the stripping. (Heat methods are best limited to those interior elements that can be safely removed from the building for stripping and reinstalled). Finally, scraping to remove heatloosened paint may gouge and scar the wood or plaster substrate if not done carefully. Rotary wire brushes cut into wood and should be avoided altogether.

Chemical stripping. Removing paint from wood and plaster features can be done with either caustic strippers (potassium or sodium hydroxide) or solvent strippers (organic compounds such as methylene chloride, methanol, or toluol). Caustic strippers are fairly fast acting, but can weaken wood fibers if left on too long, causing them to raise and

separate. They also leave alkaline residues which must be neutralized by an acidic wash (usually white vinegar which contains 4% acetic acid). It is difficult to make the neutralizing 100% effective and, when it is not, chemical reactions between the alkaline residues and the new paint may cause the paint to lose adhesion.

Methylene chloride and other organic compounds are as effective as caustic strippers, but their fumes may be both flammable and toxic. While they may leave wood and plaster surfaces free from harmful residue, the newly cleaned surface must be washed down with mineral spirits or denatured alcohol before priming in order to remove additives, such as wax, that were put in the stripper to retard its drying. All hazard warnings on the labels of chemical strippers should be heeded.

Detergent or vinegar and water. Waterbased paints can usually be scrubbed off with hot water with a detergent added. Calcimine and whitewash are difficult to remove; because of the lime or whiting content (calcium carbonate), however, they can be broken down with acids. While strong acids may work quickly, they are very dangerous. Acetic acid in its most common form, vinegar, (4% acetic acid) is often used instead. In areas where any calcimine remains and is evident as chalk, the area can be coated with white shellac, which provides a stable surface for the new paint.

Air pressure. Air pressure of 200-500 psi is effective for flat surfaces if there is a weak substrate surface bond. A flat nozzle is inserted between the paint layer and substrate, and the air pressure simply lifts the loose paint up for easy removal. When used carefully, this method is fast and causes little damage.

Patching and Repair. Once the substrate and its surface are sound and clean, free from crumbling, loose material or dust, the next step is to undercut and fill any cracks in plaster surfaces. Plaster which has lost its key and is sagging should be reattached or replaced. Friable plaster and punky wood need to be consolidated. Wood surfaces should be made as smooth as they were historically so that the paint film will cover a relatively uniform surface. Rotted wood must be removed and new wood carefully spliced in. Finally, gypsum plaster finishes can be painted as soon as the water has evaporated; a lime putty coat or traditional finish plaster can be primed almost immediately after drying as well, using alkaliresistant primers such as acrylic latex.

Priming. The importance of a primer can hardly be overstated. It is the intermediary material between the immediate substrate, which may be an old paint layer or may be bare wood, plaster, or metal (rarely stone, as around a fireplace opening), and the fresh paint itself. The primer must be capable of being absorbed to some extent by the material underneath while being compatible and cohesive with the paint to be applied on top. Most paint manufacturers will provide explicit instructions about which primers are most compatible with their paints. Those instructions should be followed.

The question of a primer for latex paint continues to be debated. Traditionalists recommend that the primer between an old oil paint and a new latex paint be an oil primer, but the improvements to latex paint in recent years have led many experts to the conclusion that today's top grade latex primers are best for latex finish paints. If a latex primer is selected, the label on the can should specify clearly that it is one which can bond to an older oil or oil/alkyd paint.

The most important general rule to remember is that softer or weaker paints should always go over harder and stronger paints. For instance, because latex is stronger than oil, an oil or oil/alkyd paint can go over a well adhered latex, but the reverse will run the risk of failure. Using primer and finish paints by a single company is a good way to guarantee compatibility.

Choosing Modern Paint Types/Finish Coats

Most frequently today, the project goal is preservation or rehabilitation. Because of the impracticality of replicating historic paints, restoration is least often undertaken. Given current laws restricting the use of toxic ingredients, such as lead, solvents, and thinners, contemporary substitute paints using safer ingredients need to be used. Many paint companies make latex paints in colors that are close to historic colors as well as appropriate gloss levels, but contain no white lead and no hazardous volatile organic compounds.

Work on historic properties generally requires the services of a qualified paint contractor who has had at least five years of experience and who can list comparable jobs that a potential client can see. Then, too, getting a sample or a mockup of any special work may be advisable before the job starts. While less experienced workers may be acceptable for preparing and priming, it is wise to have the most experienced painters on the finish work.

Oil-based / alkyd paints. Today's version of oil paint has a binder that usually contains some linseed oil (read the paint can label), but also has one of the improved synthesized oils, frequently soybased, known as alkyds. They dry hard, have flexibility, and discolor far less than linseed oil. They can also be manufactured to dry with a high sheen, and can take enough tinting pigment to create even the very deep Victorian period colors. However, they all contain volatile organic compounds, and thus are forbidden by law in some parts of the United States. They are also less simple and more dangerous to use, as cleaning up involves mineral spirits.

Traditional water-based paint and artists' brushes are being used to reproduce historic finishes within a restoration project. Photo: Courtesy, Alexis Elza.

Acrylic waterborne paints (latex). Latex paints are synthetic resins carried in water. Before the paint dries or crosslinks, it can be cleaned up with water. Early in the history of latex paints, some contained styrene/butadiene resins. Now nearly all topgrade latex paints contain acrylic resins, which are superior. Also, until fairly recently, the latex paints, while offering great strength, quick drying, and water cleanup, had some disadvantages for jobs which needed to have an historic look. Today, there are latex product lines with better gloss characteristics and more historic colors from which to choose. In addition, latex paints often have excellent color retention with very little fading. Still, it is always a good idea to buy a quart and "test paint" the color chosen for the job on site before making a total commitment.

Calcimine / whitewash. Modern waterbased paints such as calcimine can be purchased today and have much the same appearance as the early ones. The same is true of modern whitewash, although today's whitewashes do not leave the same ropy surface texture as the early ones.

Glazes. Glazes were often part of historic paint treatments. Traditionally oil and turpentine, sometimes with a scant amount of pigment, today's glazes can be formulated with a water base and are relatively simple to apply by brush. An experienced decorative painter should be consulted before deciding whether to use a glaze coat rather than a high-gloss enamel. The glaze is capable of providing protection as well as a more accurate historic appearance that includes a greater depth to the finish.

Epoxies / Urethane. These were not available until relatively recently and thus are not appropriate for replication of traditional finishes.

Applying Interior Paints

Because flat wall surfaces generally dominate an interior painting job, some flexibility in applicators is suggested below:

Brushes. Natural bristle brushes now have competition from synthetic brushes made of nylon or polyester which work well for applying either oil/alkyd or latex paints. Being harder than natural bristles, they tend to last longer. Since brushes come in a wide and very specific variety of types suited to different types of work, it is important to have a painter who will use the appropriate brush for the paint selected and for each portion of the job. One strong advantage of brushing paint on is that the paint is forced onto the surface and into all of its imperfections. Thus a good brushedon paint job may last longer if the substrate is sound and the primer and finish coats are compatible and of top quality.

Rollers. There is no harm in using a roller, or even an airless sprayer, to apply a prime coat to a large flat area. Since all contemporary commercial paints dry with a smooth surface anyway, use of a roller or sprayer is acceptable for priming, and even for a first finish coat. However, to get paint well pushed into articulated surfaces and to add some texture to larger flat surfaces, a brush is best.

Types of Modern Paint

Oilbased / alkyd: Nonvolatile oils and resins, with thinners. (Alkyds are synthetic, gelatinous resins compounded from acids and alcohol.) Accept almost any type of coloring/hiding pigments. For use on interior wood and metal.

Acrylic waterborne paints (latex): Suspension of acrylic or polyvinyl resins in water, with other resins, plus hiding and coloring pigments and extenders. Dries by evaporation. Commercially produced acrylic or latex enamels are also available in a complete range of gloss levels which are produced with the addition of various acrylic polymers. Use on interior plaster especially.

Enamels: Modern alkyd paints are adjusted with the addition of synthetic varnishes to produce a complete range of gloss levels.

Metal finishes: Paints marketed for use on metals, can either be alkyd, latex, or epoxy based, or combinations. The primers used for metals are formulated with rustinhibiting ingredients.

Special finishes: finishes such as urethane and epoxy-based paints, marketed for very high gloss surface treatments.

Finally, decorative paint work in an historic interior-- whether simple or highstyle--is well worth preserving or restoring, and when such fancy work is being undertaken, traditional tools should always be used. To simplify by using shortcut methods or rejecting painted decoration is indeed to dismiss or skew history as well as to lose the enjoyment of a true historic finish.

Summary

First, it is most important to understand the range of approaches and treatments and to make choices with as much knowledge of the original and subsequent historic paints as possible, using the ***Secretary of the Interior's Standards for the Treatment of Historic Properties*** as a framework.

A paint's patina of age expresses decades or centuries of endurance in the face of changing climate and conditions. Documenting the sequence of interior paint layers and protecting this information for future investigation should be an integral part of any historic preservation project.

When discovered, important examples of history, such as this pencilled Civil War graffiti, should be preserved. Photo: Kaye Ellen Simonson.

Except for the rare, scholarly restorations of historic interiors, most repainting jobs done today will employ modern paint formulations. Modern paints can recreate the appearance of historic colors, gloss and texture in varying degrees, but eliminate earlier toxic components such as white lead and volatile organic compounds.

CAUTION: Before Painting Know Paint Hazards and Take Action

Before undertaking any project involving paint removal, applicable State and Federal laws on lead paint abatement and disposal must be taken into account and carefully followed. State and Federal requirements may affect options available to owners on both paint removal and repainting. These laws, as well as any requirements prohibiting volatile organic compounds (VOCs), should be requested from the State Historic Preservation Officer in each State.

Below is a summary of the health hazards that owners, managers, and workers need to be aware of before removing paint and repainting:

Lead and other heavy metal compounds. In virtually all paints made before 1950, the white or "hiding" pigment was a lead compound, or more rarely, zinc oxide. Work to remove lead paint such as scraping and dry sanding releases the lead--a highly damaging heavy metal--in dust. Lead dust then enters the human system through pores of the skin and through the lungs. The use of heat for stripping also creates toxic lead fumes which can be inhaled.

To mitigate the hazards of lead paint ingestion, inhalation, or contact, it is extremely important to prevent the dust from circulating by masking room openings and removing all curtains, carpeting, and upholstered furniture. Drop cloths and masking containing lead dust should be carefully enclosed in tight plastic bags before removal. Workers and others in the room should wear High Efficiency Particulate Air (HEPA) filters for lead dust (fume filters if heat stripping is being used), change clothing just outside the room leaving the work clothes inside, and avoid any contact between bare skin (hands) and the paint being removed. Workers should also not eat, drink, or smoke where lead dust is present. Finally, anyone involved in lead paint removal should undergo periodic blood testing. After work, ordinary vacuuming is not enough to remove lead dust; special HEPA vacuums are essential. The surfaces of the room must also be given a final wash with a solution of trisodium phosphate and water, changing the washing solution often and rinsing well.

In addition to lead, early oil paints also had cobalt or other heavy metal compounds in them to accelerate drying. A small amount of mercury is also included in some latex paints to help prevent mildew and mold formation.

Volatile organic compounds (VOCs). Organic paint strippers, such as methylene chloride, and oil/alkyd paints have VOCs as their solvent base. Inhaling these fumes can lead to respiratory and other illnesses, and to cancer. Especially in closed spaces (but in the outdoor environment as well) these compounds pollute the air and can damage health.

Additional Reading

Clark, Victor S. *History of Manufacturers in the United States* Vol. III. New York: McGrawHill, 1929.

Gettens, Rutherford J. and George L. Stout. *Painting Materials: A Short Encyclopedia.* New

York: Dover Publications, 1966.

MacDonald, Marylee. *Preservation Briefs 21: Repairing Historic Flat Plaster--Walls and Ceilings.* Washington, D.C.: National Park Service, U.S. Department of the Interior, 1989.

Masury, John W. A Popular Treatise on the Art of HousePainting: Plain and Decorative. New York: D. Appleton & Co.,. 1868.

Weeks, Kay D. and David W. Look, AIA. *Preservation Briefs 10: Exterior Paint Problems on Historic Woodwork.* Washington, D.C.: National Park Service, U.S. Department of the Interior, 1982.

Winkler, Gail Caskey and Roger W. Moss. *Victorian Interior Decoration: American Interiors 1830-1900.* New York: Henry Holt and Company, 1986.

Organizations

National Paint and Coatings Association
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Home page logo: Restoration of decorative paint finishes. Photo: Sara B. Chase.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

Questions