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USMMA Historic District Property Maintenance and Repair Manual

Volume 8 – Mechanical System Elements

Sunny E. Adams and Adam D. Smith

June 2018

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Cover: Example of reference for a historic fixture (drawing left, USMMA DPW, 1919) to the current replacement fixture (photo right, ERDC-CERL, 2013).

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Volume 8 – Mechanical System Elements

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Abstract

The U.S. Merchant Marine Academy is located in Kings Point, New York. The Academy is listed on the National Register of Historic Places (#14000538). The historic district contains contributing mansions constructed during the Gold Coast Era and the Academy buildings constructed in 1942 to 1969. All buildings require regular planned maintenance and repair. The most notable cause of historic building element failure and/or decay is not because the historic building is old, but rather it is caused by an incorrect or inappropriate repair and/or basic neglect of the historic building fabric. This document is a maintenance manual compiled with as-is conditions of building materials at the Academy. The *Secretary of the Interior's Standards for the Treatment of Historic Properties on Preservation, Rehabilitation, and Repair* are discussed per material. This 8-volume report includes an overview volume plus volumes on each of the following elements: concrete, wood, brick, metal, roofing, stucco, and mechanical systems. All mentioned repair procedures are from the U.S. General Services Administration (GSA): Historic Preservation Technical Procedures and/or the National Park Service's series of Preservation Briefs. This report satisfies Section 110 of the National Historic Preservation Act (NHPA) of 1966, as amended.

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Preface

This study was conducted for the U.S. Department of Transportation Maritime Administration (MARAD) under Project Number 450153, “Historic Preservation Plan for U.S. Merchant Marine Academy.” The technical monitor was Barbara Voulgaris, Federal Preservation Officer, U.S. Department of Transportation, MARAD.

The work was performed by the Land and Heritage Conservation Branch (CNC) of the Installations Division (CN), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Dr. Michael Hargrave was Chief, CEERD-CNC; and Ms. Michelle Hanson was Chief, CEERD-CN. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Lance D. Hansen.

COL Bryan S. Green was the Commander of ERDC, and Dr. David W. Pittman was the Director.

Foreword

ERDC-CERL's effort to put together a guide to proper maintenance and repair of the historic elements at the U.S. Merchant Marine Academy has been divided into multiple volumes for ease of use by installation personnel.

This is Volume 8 of 8, and it covers guidance for proper maintenance and repair of historic mechanical systems elements at USMMA.

Please see Volume 1 for an overview of the project and the USMMA's historic context, an explanation of the Secretary of the Interior's Standards and their application, and overviews and lists of immediate concerns for the USMMA's historic exteriors and interiors.

ADAM D. SMITH
Project Manager

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1 Mechanical System Elements

NOTE: Maintenance manuals such as those produced as part of this report are a general guide for the historic materials used throughout the USMMA. Do not assume that because a particular building or a particular material on a building is not mentioned in these manuals that the material in need of maintenance or repair does not need to follow the Standards.

1.1 Electrical – lighting

Historic light fixtures and the quality of light they produce, in combination with original daylighting features, contribute significantly to the character and authenticity of historic buildings. However, many historic buildings, unfortunately, have been compromised by inappropriate lighting alterations (Alderson 2009).

Most of the historic light fixtures located on USMMA buildings are fabricated of non-ferrous metals, such as bronze, brass, or copper, and some are made of cast iron. They all use glass diffusers.

1.1.1 Immediate concerns for electrical – lighting

Successful lighting design for historic buildings considers a variety of factors for meeting multiple goals, which include but are not limited to:

- preservation of historic materials and character,
- occupant comfort,
- initial costs,
- operational costs,
- maintenance requirements,
- disposal costs and environmental impact, and
- aesthetics (Alderson 2009).

The USMMA is fortunate to have many of its original light fixtures intact and in place on its historic buildings (examples shown in Figure 1–Figure 9). An inventory of all historic lighting elements needs to be completed, and a review of all original lighting specifications should be documented for each building. All historic light fixtures (both exterior and interior) need to be retained and maintained. The USMMA should rewire historic light fixtures as necessary to extend their lifespan

On some of the USMMA historic buildings, original light fixtures have been replaced with nonhistoric lighting (examples shown in Figure 10–Figure 14). As these wear out, a program for replacement with historically appropriate light fixtures needs to be developed.

Figure 1. Original light fixture at portico entrance to Fulton Hall (ERDC-CERL, 2013).

Figure 2. Original light fixture on the west portico of O'Hara Hall (ERDC-CERL, 2015).

Figure 3. Original light fixture on the portico of Delano Hall (ERDC-CERL, 2015).

Figure 4. Original light fixture at the entrance of Land Hall (ERDC-CERL, 2015).

Figure 5. One of the original light fixtures at the Eldridge Pool showers (ERDC-CERL, 2015).

Figure 6. One of the original light fixtures at the Mariners' Memorial Chapel (ERDC-CERL, 2015).

Figure 7. Original wall-mounted copper light fixture with original colored-glass diffusers at the Mariners' Memorial Chapel (ERDC-CERL, 2015).

Figure 8. One of the original light fixtures at Vickery Gate (ERDC-CERL, 2015).

Figure 9. Original light fixture at Bland Library (ERDC-CERL, 2015).

Figure 10. Replacement light fixture on Bowditch Hall (ERDC-CERL, 2015).

Figure 11. Replacement light fixture on Fulton Hall with shadow of original light fixture location on wall (ERDC-CERL, 2015).

Figure 12. Replacement light fixture on O'Hara Hall with shadow of original light fixture location beneath it on wall (ERDC-CERL, 2015).

Figure 13. Non-original light fixture on Vickery Gate (ERDC-CERL, 2015).

Figure 14. Non-original light fixture on Vickery Gate (ERDC-CERL, 2015).

1.1.2 Guidelines, briefs, bulletins, and sources for electrical – lighting

In addition to the information contained in this manual, the authors have compiled the following federal resource publications (reproduced here for convenience, with online links given in References) to inform managers about standards, guidelines, and procedures for understanding architecture, and caring for, preserving, and rehabilitating historic buildings with emphasis on historic lighting fixtures (see subsections 1.1.2.1–1.1.2.5).

1.1.2.1 Historic lighting reproduction (GSA 2017a)

U.S. General Services Administration

Sources of Historic Lighting Reproductions

Procedure code:

1650001R

Source:

Technology & Conservation, Summer/Fall 1992, pp. 22-24

Division:

Electrical

Section:

Lighting

Last Modified:

01/04/2017

This reference list includes manufacturers and suppliers of historic lighting reproductions as identified in the Summer/Fall 1992 issue of Technology & Conservation.

- A.K. Exteriors (outdoor wall lanterns)
- American Lantern Company (chandeliers, outdoor wall lanterns, post lights (Colonial Williamsburg style))
- Appleton Electric Company
- Classic Illumination, Inc. (ceiling mounted units (1900-present), chandeliers, wall sconces (1870-present))
- Edison Price Lighting (ceiling mounted units)
- Gates Moore Lighting (chandeliers, outdoor wall lanterns, post lights)
- Gibson and Gibson Antique Lighting (ceiling mounted units, floor lamps, wall sconces (1880s-1940s styles))
- Herwig Lighting (outdoor wall lanterns, post lights)
- Historical Arts & Casting, Inc. (chandeliers)
- King's Chandelier Co. (chandeliers, wall sconces (18th and 19th century))
- Lighting by Hammerworks
- Lite Makers, Inc.
- Luxo Lamps Corporation
- Metropolitan Lighting Fixture Co., Inc.
- Newstamp Lighting
- Progress Lighting
- Rambusch Lighting
- Saint Louis Antique Lighting Co.
- Spring City Electrical Mfg. Co.
- Sternberg Vintage Lighting
- Sterner Lighting Systems Inc. (chandeliers, outdoor wall lanterns, post lights)
- Tower Lighting (chandeliers, outdoor wall lanterns, post lights (Colonial style))
- Versailles Lighting Inc. (ceiling mounted units, chandeliers, wall sconces)
- Victorian Lighting Works, Inc. (chandeliers, wall sconces)

1.1.2.2 Cleaning and painting cast iron lamps (GSA 2016a)

U.S. General Services Administration

Cleaning And Painting Cast Iron Lamps

Procedure code:

1651005S

Source:

National Capitol Region Specifications

Division:

Electrical

Section:

Lighting Fixtures

Last Modified:

07/22/2016

CAUTION: Mechanical/abrasive methods of cleaning may damage historic fabric. This method of cleaning should be performed only by an experienced professional and only upon approval from the regional historic preservation officer.

The cleaning or stripping of metals may involve the use of abrasives, liquids or solvents which may splash or run off onto adjacent materials. Take special care to protect all adjacent materials, and do not use this procedure on metals other than those specified in the summary.

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 (from preservation brief 28, "painting historic interiors".) The environmental protection agency (epa) regional office and/or the state office of environmental quality.

PART 1---GENERAL**1.01 SUMMARY**

- A. This procedure includes guidance on filling open cracks, cleaning and painting iron lamp standards.
- B. For information on inspecting for cast-iron failures, see 05010-01-S. For general information on the characteristics, uses and problems associated with cast- iron, see 04720-01-S.
- C. See 01100-07-S for general project guidelines to be reviewed along with this procedure. These guidelines cover the following sections:
 - 1. Safety Precautions
 - 2. Historic Structures Precautions
 - 3. Submittals
 - 4. Quality Assurance
 - 5. Delivery, Storage and Handling
 - 6. Project/Site Conditions
 - 7. Sequencing and Scheduling

8. General Protection (Surface and Surrounding)

These guidelines should be reviewed prior to performing this procedure and should be followed, when applicable, along with recommendations from the Regional Historic Preservation Officer (RHPO).

1.02 REFERENCES

- A. The Society for Protective Coatings (formerly Steel Structures Painting Council)
www.sspc.org

1.03 PROJECT/SITE CONDITIONS

- A. Environmental Requirements: Do not apply finish material when temperature is below 50 degrees F. and falling. Do not apply paint on surfaces in direct sunlight. Do not apply finishes in spaces where dust is being generated, which would speck the finish.

PART 2---PRODUCTS

2.01 MANUFACTURERS

- A. Benjamin Moore
<http://www.benjaminmoore.com/>
01 Paragon Drive
Montvale NJ 07645
info@benjaminmoore.com
855-724-6802
- B. Sherwin-Williams
www.sherwin-williams.com
Cleveland, OH
216-566-2000
- C. Martin Senour
<http://www.martinsenour.com/>
1-800-677-5270
- D. ITW Devcon, Inc.
www.devcon.com
Danvers, MA
1-800-933-8266

2.02 MATERIALS

NOTE: Chemical products are sometimes sold under a common name. This usually means that the substance is not as pure as the same chemical sold under its chemical name. The grade of purity of common name substances, however, is usually adequate for stain removal work, and these products should be purchased when available, as they tend to be less expensive. Common names are indicated below by an asterisk (*).

- A. Mineral spirits:
 - 1. QA petroleum distillate that is used especially as a paint or varnish thinner.
 - 2. Other chemical or common names include Benzine* (not Benzene); Naphtha*; Petroleum spirits*; Solvent naphtha*.
 - 3. Potential Hazards: TOXIC AND FLAMMABLE.
 - 4. Safety Precautions:
 - a. AVOID REPEATED OR PROLONGED SKIN CONTACT.
 - b. ALWAYS wear rubber gloves when handling mineral spirits.
 - c. If any chemical is splashed onto the skin, wash immediately with soap and water.

5. Available from construction specialties distributor, hardware store, paint store, or printer's supply distributor.
- B. Emery paper
- C. Flint sandpaper
- D. Fine steel wool
- E. 600 grit aluminum oxide
- F. Rust remover solution containing orthophosphoric acid. Several are available in gel form from retail outlets.
- G. Soft rags
- H. Clean, potable water
- I. Sealant: Polysulfide sealant, color as approved by RHPO.
- J. Metal Filler: Steel filled two part epoxy metal filler, putty grade, such as "Plastic Steel 5 Minute Putty (SF)" (Devcon Corporation), or approved equal.
- K. Paint for Metal Paint and Finish Products, such as those by Benjamin Moore, Sherwin Williams, Martin Senour, or approved equal. See also 05010-13-S for general information on the advantages and limitations of various paint and primer types.
 1. Paint products shall be fresh and well ground; shall not settle readily, cake or thicken in the container; shall be broken up readily with a paddle to a smooth consistency; and shall have easy application properties.
 2. Other painting materials, such as linseed oil, turpentine, mineral spirits, and miscellaneous thickeners, shall be the highest quality of an approved manufacturer.
 3. Colors: Primer coats to be clearly different in color from each other; base coat to be clearly different from primer or finish coat; finish coat to be approved by RHPO.
 4. Dry Film Thickness: Each coat to be 2 mils.

2.03 EQUIPMENT

- A. Rubber gloves
- B. Eye and skin protection
- C. Paint scrappers and putty knives
- D. Ball peen hammer
- E. Sanding blocks, sanding sponges, sanding wheels
- F. Wire brushes
- G. Stiff natural bristle brushes
- H. Rotary wire wheels
- I. Proper, heavy-duty extension cords
- J. Air-abrasive cleaning equipment (80-100 psi) for use with fine grit dry and wet abrasives. Consult RHPO.
- K. Water hose

PART 3---EXECUTION

3.01 EXAMINATION

- A. Before work is begun on removing the existing paint film or otherwise preparing the surface all sources of excess moisture shall be determined and repaired as required.
- B. Execute test samples of the cleaning methods specified in this procedure to determine which method(s) are to be used. Sample areas shall be selected by the RHPO and shall include at least one ornamental area and one flat area, or as necessary to include all surface types likely to be encountered in this work.
- C. Method(s) used in the actual cleaning shall be the one(s) which provide the necessary level of cleanliness with the least amount of surface alteration. Final selection of methods shall be made by the RHPO.

3.02 PREPARATION

- A. Protection:

1. Protect adjacent surfaces, including grass, shrubs and trees with paper, drop cloths and other means. Items not to be painted which are in contact with or adjacent to painted surfaces shall be removed or protected prior to surface preparation and painting operations. All methods of enclosure and protection should be approved by the supervisor.
 2. Work area shall be sealed to prevent the spread of dust, debris and water beyond the work site, and to assist in the collection of contaminants.
 3. Provide protection boards to vulnerable decorative work and maintain for the duration of operations.
 4. All waste material shall be collected at the end of each work day and properly disposed of. It is considered Hazardous Waste.
 5. After each days paint removal work is complete, area shall be vacuumed with machines equipped with HEPA (High Efficiency Particulate Air) filters to insure all lead dust has been removed.
- B. Surface Preparation: Determine surfaces to which painting and finishing are to be applied are even, smooth, sound, clean, dry and free from defects affecting proper application. Correct or report defective surfaces to Contracting Officer.

3.03 ERECTION, INSTALLATION, APPLICATION

A. Metal Cleaning, General:

NOTE: REMOVE ONLY AS MUCH PAINT AND RUST EACH DAY AS CAN BE PRIMED THAT SAME DAY. BARE IRON AND STEEL WILL BEGIN TO RUST AGAIN WITHIN A MATTER OF HOURS. IT SHOULD NOT BE ALLOWED TO SIT UNPROTECTED OVERNIGHT.

1. Remove all paint and scale from all surfaces to bare metal.
2. Dismantle iron lamp standards.

B. Mechanical/Abrasive Rust/Paint Removal: OBTAIN RHPO APPROVAL BEFORE PROCEEDING WITH WORK.

1. To determine the degree of deterioration and the level of paint removal required, clear away all dust and debris followed by rub-down with mineral spirits.
2. To remove light rust and flaking, peeling paint:
 - a. Begin with emery paper or aluminum oxide sandpaper.
 - b. Use scrapers to get under loose paint and into crevices.
 - c. Use a wire brush, or an electric drill with a special wire brush or rotary sandpaper whip attachment if above two methods do not remove paint.

C. Air-abrasive Paint Removal: OBTAIN RHPO APPROVAL BEFORE PROCEEDING WITH WORK.

- A. NOTE: While air abrasive cleaning (commonly known as sandblasting) is destructive for softer building materials, iron, a hard material with a natural uneven surface, will not be noticeably damaged by its careful use.
- B. CAUTION: Do not use air-abrasive cleaning methods in the following situations:
 - A. On thin sections or fine, intricate details of wrought iron features.
 - B. On zinc and galvanized iron and steel.
 - C. On features for which the original surface texture is an integral part of the design (air-abrasive cleaning will alter original surface texture and appearance).
 - D. On stainless steel features.
- C. Air pressures at the compressor shall be between 40 psi to 70 psi.
- D. Grit size shall be in the range of #10 to #45, i.e. copper slag. Other abrasives, such as ground walnut shells, or other abrasive methods such a glass bead peening, may also be appropriate but should be performed only under the direction of an architectural conservator and/or the RHPO.
- E. A pencil-point nozzle shall be used to allow more complete control. Nozzle shall allow for independent control over air, water and abrasive and should be held no closer than 12" from the surface to be cleaned.
- F. Flush all surfaces with water to remove all traces of slurry and spent abrasive. Final rinse shall contain rust inhibitor with no more than 5000 ppm.

CAUTION: Larger concentrations of rust inhibitor will result in the deposition of salts on the metal surfaces which will cause the paint to peel.

- D. Dry surfaces immediately, especially any horizontal surfaces or water traps which might collect water.
- E. Prime as soon as possible after surfaces have been dried but before rust has a chance to reform. See 05010-13-S for general information describing paints and primers for cast-iron. Apply second prime coat after first has dried completely. Secure approval of surface preparation and each coat prior to proceeding with the next.
- F. Re-assemble cast iron lamp standards. Seal all open joints between metal elements and metal and masonry with polyethylene backer rods and polysulfide sealant. Joint shall be concave with smooth finish.
- G. Fill all holes, depressions and cracks with metal filler and sand to conform with surrounding contours. See 05010-12-R for guidance.
- H. Prime and paint all surfaces. Brush apply two finish coats of paint.
 - 1. Apply material evenly without runs, sags, or other defects. Work each coat onto the material being coated at an average rate of coverage recommended. Cover surfaces complete to provide uniform color and appearance with a minimum of dry film thickness of 2 mils. Make edges of paint adjoining other materials or colors sharp and clean, and without overlaps.
 - 2. Drying time: Minimum time as recommended. Do not apply succeeding coats until the undercoat is thoroughly dry.
 - 3. For guidance see 05010-13-S "Primers and Paints for Wrought Iron, Cast Iron and Steel", 05010-18-R "Applying a Sacrificial Coating to Wrought Iron, Cast Iron and Steel", and 09900-07-S "General Guidelines for Painting Exterior and Interior Surfaces".

3.04 ADJUSTING/CLEANING

- A. Cleanup: Remove all paint where it has spilled or spattered. Do not drip any paint on stone. No chemical cleaners allowed.

3.05 PROTECTION

- A. Protect cleaned or final finishes from damage during building or project cleaning period by use of temporary protective coverings approved by RHPO. Remove protective covering at time of Substantial Completion.

1.1.2.3 Cleaning ornamental bronze light fixtures (GSA 2016b)

U.S. General Services Administration

Cleaning Ornamental Bronze Light Fixtures

Procedure code:

1651003S

Source:

National Capitol Region Specifications

Division:

Electrical

Section:

Lighting Fixtures

Last Modified:

08/09/2016

PART 1---GENERAL

1.01 SUMMARY

- A. This procedure includes guidance on cleaning existing interior ornamental bronze lighting fixtures.
- B. See "General Project Guidelines" for general project guidelines to be reviewed along with this procedure. These guidelines cover the following sections:
 - 1. Safety Precautions
 - 2. Historic Structures Precautions
 - 3. Submittals
 - 4. Quality Assurance
 - 5. Delivery, Storage and Handling
 - 6. Project/Site Conditions
 - 7. Sequencing and Scheduling
 - 8. General Protection (Surface and Surrounding)These guidelines should be reviewed prior to performing this procedure and should be followed, when applicable, along with recommendations from the Regional Historic Preservation Officer (RHPO).

PART 2---PRODUCTS

2.01 MATERIALS

- A. Mild Soap: Ivory or a mild detergent with pH of approximately 8.0.
- B. Cloth: Clean cotton waste.
- C. Clean, potable water.

PART 3---EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION

- A. Erect a stable working platform, which will allow easy access to all elements of the lighting fixture and its hangers. Support fixture so that no additional pressure will be placed on its hangers during the cleaning operation.

1.1.2.4 Replacing ornamental bronze light fixtures (GSA 2017b)

U.S. General Services Administration

Replacing Ornamental Bronze Light Fixtures

Procedure code:

1651002S

Source:

National Capitol Region Specifications

Division:

Electrical

Section:

Lighting Fixtures

Last Modified:

07/22/2016

PART 1---GENERAL

1.01 SUMMARY

- A. This procedure includes guidance on the replacement of missing interior ornamental lighting fixtures to match the originals.
- B. See 01100-07-S for general project guidelines to be reviewed along with this procedure. These guidelines cover the following sections:
 - 1. Safety Precautions
 - 2. Historic Structures Precautions
 - 3. Submittals
 - 4. Quality Assurance
 - 5. Delivery, Storage and Handling
 - 6. Project/Site Conditions
 - 7. Sequencing and Scheduling
 - 8. General Protection (Surface and Surrounding)These guidelines should be reviewed prior to performing this procedure and should be followed, when applicable, along with recommendations from the Regional Historic Preservation Officer (RHPO).

1.02 SUBMITTALS

- A. Shop Drawings: All fixtures are to be reproduced from surviving references and surviving example fixtures. Fabricators shall be furnished with clean full-size drawings produced from existing fixtures. The lighting fixture fabricator shall furnish copies of shop drawings for the approval of the Contracting Officer.
- B. Samples: Submit a sample of each fixture indicating fabricators technique.

PART 2---PRODUCTS

2.01 MATERIALS

- A. Metals:

1. All exposed parts of fixtures are to be of the materials as specified.
 2. Bronze: Cast bronze items fabricated from statuary bronze alloy and highly polished with no pitting of surface.
 3. If the contractor desires to use alloys in lieu of those herein specified, the composition of the same, together with finished samples of the metals must be submitted to the Contracting Officer.
- B. Castings: Patterns for castings shall be iron. The modeling of patterns must be crisp, true to detail and uniform in execution. All details of cast ornamentation must be plainly brought out by hand finishing. Where ornaments are made in parts, the joints must be brazed and designed so as to cause no break in the ornamentation. All burrs and sharp edges must be removed from wire ways.
- C. Wiring: Wiring for new fixtures shall utilize existing conduits where possible. Any damage to decorative plaster ceilings, cornice or pilasters shall be repaired to match existing (see 09200-03-S and 09200-05-R for guidance). Wiring shall conform to the National Electric Code.
- D. Finishes: The finish of bronze fixtures shall be hand finished statuary bronze. It shall be produced by polishing to a bright bronze color and then oxidizing to color, directed by the Contracting Officer.

PART 3---EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION

- A. Replace missing fixtures identical to surviving original examples. Bronze finish should match the clean finish of existing fixtures.
- B. For guidance on cleaning existing bronze fixtures, see 16510-02-R. For guidance on cleaning, polishing, oiling and patinating bronze, see 05010-01-R and 05010-22-R.

1.1.2.5 Restoring wrought-iron wall fixtures (GSA 2016c)

U.S. General Services Administration

Restoring Original Wrought-Iron Wall Luminaries

Procedure code:

1651001S

Source:

US Custom House/Portland, OR - GSA/PBS, 6-28-91

Division:

Electrical

Section:

Lighting Fixtures

Last Modified:

08/09/2016

PART 1---GENERAL

1.01 SUMMARY

- A. This procedure includes guidance on restoring and rehabilitating existing antique wrought iron bracket wall luminaries.
NOTE: This work should be performed by an approved and experienced lighting fixture restoration or custom fabrication contractor.
- B. This work includes preserving the original qualities of the existing fixtures and rehabilitating them for continued service as installed by repairing all damage and by retrofitting the fixtures with new electrical and lighting equipment.

PART 2---PRODUCTS

2.01 MANUFACTURERS

- A. Saint Louis Antique Lighting Company
St. Louis, MO
- B. Gibson Lighting
Chula Vista, CA
- C. Rambusch Lighting

2.02 MATERIALS

- A. Wrought-iron and glazing to match the existing (St. Louis Antique Lighting Co., Gibson and Gibson Antique Lighting), or approved equal.
- B. Electrical equipment to be "Specifications Grade", weather resistant, and low maintenance type.
- C. Finishes: Match original wrought-iron finish including two coats rust inhibiting ferrous metal primer.

PART 3---EXECUTION

3.01 PREPARATION

A. Surface Preparation:

1. Mark fixtures with a tag or identifying label to record the original location where installed; otherwise assume all risk for improper reinstallation.
2. Remove fixtures to shop and disassemble, exercising care to keep original parts together for reassembly.
3. Save original glazing for reinstallation after cleaning.

3.02 ERECTION, INSTALLATION, APPLICATION

- A. Clean fixtures and parts to remove dirt, rust, and weathered paint.
- B. Remove all loose rust by wire brushing, sanding, or light sand or bead blasting as required, but do not erode original metal, and "white metal" cleaning is not required.
- C. Repair or replace any broken, missing, or damaged member matching original workmanship and fastenings.
1. Replace broken and missing glazing in kind and reinstall existing glazing with restored glazing clips and sealing compound as required, all glazing to be washed clean.
 2. Inspect and recondition or replace all fastenings, fixture mounting, hinges, and latches to restore to original strength and function.
- D. Refit each fixture with new wiring, lampholder sockets, and lamps to restore the appearance and function for electric lighting.
1. Lampholder sockets to be weather resistant type, porcelain or heavy duty cast metal, with all brass sockets and contacts, provided with weather seal gasket as required.
 2. Retrofit fixtures for long-life, energy efficient lamp types if available for this application and the appearance is acceptable to the RHPO, otherwise continue existing lamp type installation.
- NOTE: USE CAUTION AS SOME HIGH-INTENSITY LIGHTING PRODUCES HIGHER LEVELS OF HEAT THAN THE FIXTURE WAS DESIGNED TO ACCOMMODATE AND MAY REQUIRE ADDITIONAL VENTILATION OR CLEARANCE.
- CONSULT EXPERIENCED LIGHTING PROFESSIONALS WHEN CHANGING THE TYPE OF LIGHTING IN A FIXTURE.
- E. Finishes: Repaint all metal to restore wrought-iron finish and to make all hardware match.
- F. Reinstall restored and rehabilitated fixtures in their original locations using new fastenings as required, each permanently and vandal resistant mounted, plumb and straight, without looseness and movement, and flush with supporting masonry.

1.2 Heating and air conditioning

For historic properties it is critical to understand what spaces, features, and finishes are historic in the building, what should be retained, and what the realistic heating, ventilating, and cooling needs are for the building, its occupants, and its contents (Park 1991).

1.2.1 Immediate concerns for heating and air conditioning

There are several individual air conditioners that are set within windows and through exterior walls of the USMMA historic buildings (e.g., Figure 16–Figure 21). This can be visually as well as physically damaging to the building. Improper maintenance can contribute to problems (Figure 22–Figure 25).

Radiators in the buildings where the interiors are considered character defining would be identified as a significant element of the interior (e.g., Figure 15). In any work to upgrade the mechanical system, the radiator would be retained and preserved, even if non-functioning. In some cases, roof ventilation units are also character-defining elements (e.g., Figure 26).

Figure 15. Historic radiator in one of the Wiley Hall bathrooms (ERDC-CERL, 2015).

Figure 16. Window air conditioner units like here at Patten Hall can greatly impact the historic character of a contributing building (ERDC-CERL, 2015).

Figure 17. Window air conditioner unit at O'Hara Hall [note staining on concrete blocks below from one previously located here] (ERDC-CERL, 2015).

Figure 18. Example of a window air conditioner unit at Patten Hall that is leaking on the concrete materials below (ERDC-CERL, 2015).

Figure 19. Example of a wall air conditioner unit (ERDC-CERL, 2015).

Figure 20. Example of a wall air conditioner unit with replacement concrete blocks below it at Vickery Gate (ERDC-CERL, 2015).

Figure 21. Window air conditioner units in the fanlight portion of windows at Land Hall (ERDC-CERL, 2015).

Figure 22. Interior mechanical units need to be drained appropriately so that water does not impact historic elements (ERDC-CERL, 2015).

Figure 23. All vegetation should be cleared around the area near a mechanical system unit (ERDC-CERL, 2015).

Figure 24. Make sure that nonhistoric exterior mechanical system units are appropriately screened like this system at the Mariners' Memorial Chapel (ERDC-CERL, 2015).

Figure 25. When removing nonhistoric mechanical systems or components, restore other historic elements correctly—unlike this example highlighted with the red box (ERDC-CERL, 2015).

Figure 26. Original roof ventilators on Delano Hall are character-defining features (ERDC-CERL, 2015).

1.2.2 Guidelines, briefs, bulletins, and sources for heating and air conditioning

In addition to the information contained in this manual, the authors have compiled the following federal resource publications (reproduced here for convenience, with links for online access given in References) to inform managers about standards, guidelines, and procedures for understanding architecture, and caring for, preserving, and rehabilitating historic buildings with emphasis on mechanical systems such as heating and air conditioning that are important in defining the overall character of the building (see subsections 1.2.2.1 and 1.2.2.2).

1.2.2.1 Heating, ventilating, and cooling historic buildings – problems and recommended approaches (Park 1991 – Preservation Brief #24)

Technical Preservation Services

National Park Service
U.S. Department of the Interior

[Home](#) > [How to Preserve](#) > [Preservation Briefs](#) > 24 Heating, Ventilating, and Cooling

Some of the web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new and in color; Captions are simplified and some complex charts are omitted. To order hard copies of the Briefs, see [Printed Publications](#)®.

PRESERVATION BRIEFS

24

Heating, Ventilating, and Cooling Historic Buildings—Problems and Recommended Approaches

Sharon C. Park, AIA

- [History of Mechanical Systems](#)
- [Climate Control and Preservation](#)
- [Planning the New System](#)
- [Overview of HVAC Systems](#)
- [Designing the New System](#)
- [Systems Performance and Maintenance](#)
- [HVAC Dos and Don'ts](#)
- [Summary and References](#)
- [Reading List](#)
- [Download the PDF](#)

Historic boiler in functioning condition. Photo: NPS files.

The need for modern mechanical systems is one of the most common reasons to undertake work on historic buildings. Such work includes upgrading older mechanical systems, improving the energy efficiency of existing buildings, installing new heating, ventilation or air conditioning (HVAC) systems, or—particularly for museums—installing a climate control system with humidification and dehumidification capabilities. Decisions to install new HVAC or climate control systems often result from concern for occupant health and comfort, the desire to make older buildings marketable, or the need to provide specialized environments for operating computers, storing artifacts, or displaying museum collections. Unfortunately, occupant comfort and concerns for the objects within the building are sometimes given greater consideration than the building itself. In too many cases, applying modern standards of interior climate comfort to historic buildings has proven detrimental to historic materials and decorative finishes.

This Preservation Brief underscores the importance of careful planning in order to balance the preservation objectives with interior climate needs of the building. It is not intended as a technical guide to calculate tonnage or to size piping or ductwork. Rather, this Brief identifies some of the problems associated with installing mechanical systems in historic buildings and recommends approaches to minimizing the physical and visual damage associated with installing and maintaining these new or upgraded systems.

Historic buildings are not easily adapted to house modern precision mechanical systems. Careful planning must be provided early on to ensure that decisions made during the design and installation phases of a new system are appropriate. Since new mechanical and other related systems, such as electrical and fire suppression, can use up to 10% of a building's

square footage and 30%–40% of an overall rehabilitation budget, decisions must be made in a systematic and coordinated manner. The installation of inappropriate mechanical systems may result in any or all of the following:

- large sections of historic materials are removed to install or house new systems.
- historic structural systems are weakened by carrying the weight of, and sustaining vibrations from, large equipment.
- moisture introduced into the building as part of a new system migrates into historic materials and causes damage, including biodegradation, freeze/thaw action, and surface staining.
- exterior cladding or interior finishes are stripped to install new vapor barriers and insulation.
- historic finishes, features, and spaces are altered by dropped ceilings and boxed chases or by poorly located grilles, registers, and equipment.
- systems that are too large or too small are installed before there is a clearly planned use or a new tenant.

The dropped ceilings covering an air conditioning system also cover the historic windows, altering their proportion and resulting in loss of the historic character. Photo: NPS files.

For historic properties it is critical to understand what spaces, features, and finishes are historic in the building, what should be retained, and what the realistic heating, ventilating, and cooling needs are for the building, its occupants, and its contents. A systematic approach, involving preservation planning, preservation design, and a follow-up program of monitoring and maintenance, can ensure that new systems are successfully added—or existing systems are suitably upgraded—while preserving the historic integrity of the building.

No set formula exists for determining what type of mechanical system is best for a specific building. Each building and its needs must be evaluated separately. Some buildings will be so significant that every effort must be made to protect the historic materials and systems in place with minimal intrusion from new systems. Some buildings will have museum collections that need special climate control. In such cases, curatorial needs must be considered—but not to the ultimate detriment of the historic building resource. Other buildings will be rehabilitated for commercial

use. For them, a variety of systems might be acceptable, as long as significant spaces, features, and finishes are retained.

Most mechanical systems require upgrading or replacement within 15–30 years due to wear and tear or the availability of improved technology. Therefore, historic buildings should not be greatly altered or otherwise sacrificed in an effort to meet short-term systems objectives.

History of Mechanical Systems

The history of mechanical systems in buildings involves a study of inventions and ingenuity as building owners, architects, and engineers devised ways to improve the interior climate of their buildings. Following are highlights in the evolution of heating, ventilating, and cooling systems in historic buildings.

Eighteenth Century

Early heating and ventilation in America relied upon common sense methods of managing the environment. Builders purposely sited houses to capture winter sun and prevailing summer cross breezes; they chose materials that could help protect the inhabitants from the elements, and took precautions against precipitation and damaging drainage patterns. The location and sizes of windows, doors, porches, and the floor plan itself often evolved to maximize ventilation. Heating was primarily from fireplaces or stoves and, therefore, was at the source of delivery. In 1744, Benjamin Franklin designed his "Pennsylvania stove" with a fresh air intake in order to maximize the heat radiated into the room and to minimize annoying smoke.

Thermal insulation was rudimentary—often wattle and daub, brick and wood nogging. The comfort level for occupants was low, but the relatively small difference between internal and external temperatures and relative humidity allowed building materials to expand and contract with the seasons.

Regional styles and architectural features reflected regional climates. In warm, dry and sunny climates, thick adobe walls offered shelter from the sun and kept the inside temperatures cool. Verandas, courtyards, porches, and high ceilings also reduced the impact of the sun. Hot and humid climates called for elevated living floors, louvered grilles and shutters, balconies, and interior courtyards to help circulate air.

Nineteenth Century

19th century buildings used porches, cupolas, and awnings to make them

The industrial revolution provided the technological means for controlling the environment for the first time. The dual developments of steam energy from coal and industrial mass production made possible early central heating systems with distribution of heated air or steam using metal ducts or pipes. Improvements were made to early wrought iron boilers and by late century, steam and low pressure hot water radiator systems were in common use, both in offices and residences. Some large institutional buildings heated air in furnaces and distributed it throughout the building in brick flues with a network of metal pipes delivering heated air to individual rooms. Residential designs of the period often used gravity hot air systems utilizing decorative floor and ceiling grilles.

more comfortable in the summer.
Photo: NPS files.

Ventilation became more scientific and the introduction of fresh air into buildings became an important component of heating and cooling. Improved forced air ventilation became possible in mid-century with the introduction of power-driven fans. Architectural features such as porches, awnings, window and door transoms, large openwork iron roof trusses, roof monitors, cupolas, skylights and clerestory windows helped to dissipate heat and provide healthy ventilation.

Cavity wall construction, popular in masonry structures, improved the insulating qualities of a building and also provided a natural cavity for the dissipation of moisture produced on the interior of the building. In some buildings, cinder chips and broken masonry filler between structural iron beams and jack arch floor vaults provided thermal insulation as well as fireproofing. Mineral wool and cork were new sources of lightweight insulation and were forerunners of contemporary batt and blanket insulation.

The technology of the age, however, was not sufficient to produce "tight" buildings. There was still only a moderate difference between internal and external temperatures. This was due, in part, to the limitations of early insulation, the almost exclusive use of single glazed windows, and the absence of airtight construction. The presence of ventilating fans and the reliance on architectural features, such as operable windows, cupolas and transoms, allowed sufficient air movement to keep buildings well ventilated. Building materials could behave in a fairly traditional way, expanding and contracting with the seasons.

Twentieth Century

A return air grille is successfully screened behind the arch. Photo: NPS files.

The twentieth century saw intensive development of new technologies and the notion of fully integrating mechanical systems. Oil and gas furnaces developed in the nineteenth century were improved and made more efficient, with electricity becoming the critical source of power for building systems in the latter half of the century. Forced air heating systems with ducts and registers became popular for all types of buildings and allowed architects to experiment with architectural forms free from mechanical encumbrances.

In the 1920s large-scale theaters and auditoriums introduced central air conditioning, and by mid-century forced air systems which combined heating and air conditioning in the same ductwork set a new standard for comfort and convenience. The combination and coordination of a variety of systems came together in the post-World War II high-rise buildings; complex heating and air conditioning plants, electric elevators, mechanical towers, ventilation fans, and full service electric lighting were integrated into the building's design.

The insulating qualities of building materials improved. Synthetic materials, such as spun fiberglass batt insulation, were fully developed by mid-century. Prototypes of insulated thermal glazing and integral storm window systems were promoted in construction journals. Caulking to seal out perimeter air around window and door openings became a standard construction detail.

The last quarter of the twentieth century has seen making HVAC systems more energy efficient and better integrated. The use of vapor barriers to control moisture migration, thermally efficient windows, caulking and gaskets, compressed thin wall insulation, has become standard practice. New integrated systems now combine interior climate control with fire suppression, lighting, air filtration, temperature and humidity control, and security detection. Computers regulate the performance of these integrated systems based on the time of day, day of the week, occupancy, and outside ambient temperature.

Climate Control and Preservation

Although twentieth century mechanical systems technology has had a tremendous impact on making historic buildings comfortable, the introduction of these new systems in older buildings is not without problems. The attempt to meet and maintain modern climate control standards may in fact be damaging to historic resources. Modern systems are often over-designed to compensate for inherent inefficiencies of some historic buildings materials and plan layouts. Energy retrofit measures, such as installing exterior wall insulation and vapor barriers or the sealing of operable window and vents, ultimately affect the performance and can reduce the life of aging historic materials.

In general, the greater the differential between the interior and exterior temperature and humidity levels, the greater the potential for damage. As natural vapor pressure moves moisture from a warm area to a colder, dryer area, condensation will occur on or in building materials in the colder area. Too little humidity in winter, for example, can dry and crack historic wooden or painted surfaces. Too much humidity in winter causes moisture to collect on cold surfaces, such as windows, or to migrate into walls. As a result, this condensation deteriorates wooden or metal windows and causes rotting of walls and wooden structural elements, dampening insulation and holding moisture against exterior surfaces. Moisture migration through walls can cause the corrosion of metal anchors, angles, nails or wire lath, can blister and peel exterior paint, or can leave efflorescence and salt deposits on exterior masonry. In cold climates, freeze-thaw damage can result from excessive moisture in external walls.

Complex mechanical systems for institutional buildings may require a central control room. Photo: NPS files.

To avoid these types of damage to a historic building, it is important to understand how building components work together as a system. Methods for controlling interior temperature and humidity and improving ventilation must be considered in any new or upgraded HVAC or climate control system. While certain energy retrofit measures will have a positive effect on the overall building, installing effective vapor barriers in historic walls is difficult and often results in destruction of significant historic materials.

Planning the New System

Climate control systems are generally classified according to the medium used to condition the temperature: air, water, or a combination of both. The complexity of choices facing a building owner or manager means that a systematic approach is critical in determining the most suitable system for a building, its contents, and its occupants. No matter which system is installed, a change in the interior climate will result. This physical change will in turn affect how the building materials perform. New registers, grilles, cabinets, or other accessories associated with the new mechanical system will also visually change the interior (and sometimes the exterior) appearance of the building. Regardless of the type or extent of a mechanical system, the owner of a historic building should know before a system is installed what it will look like and what problems can be anticipated during the life of that system. The potential harm to a building and costs to an owner of selecting the wrong mechanical system are very great.

The use of a building and its contents will largely determine the best type of mechanical system. The historic building materials and construction technology as well as the size and availability of secondary spaces within the historic structure will affect the choice of a system. It may be necessary to investigate a combination of systems. In each case, the needs of the user, the needs of the building, and the needs of a collection or equipment must be considered. It may not be necessary to have a comprehensive climate control system if climate-sensitive objects can be accommodated in special areas or climate-controlled display cases. It may not be necessary to have central air conditioning in a mild climate if natural ventilation systems can be improved through the use of operable windows, awnings, exhaust fans, and other "lowtech" means. Modern standards for climate control developed for new construction may not be achievable or desirable for historic buildings. In each case, the lowest level of intervention needed to successfully accomplish the job should be selected.

Before a system is chosen, the following planning steps are recommended:

1. Determine the use of the building. The proposed use of the building (museum, commercial, residential, retail) will influence the type of system that should be installed. The number of people and functions to be housed in a building will establish the level of comfort and service that must be provided. Avoid uses that require major modifications to significant architectural spaces. What is the intensity of use of the building: intermittent or constant use, special events or seasonal events? Will the use of the building require major new services such as restaurants, laundries, kitchens, locker rooms, or other areas that generate moisture that may exacerbate climate control within the historic space? In the context of historic preservation, uses that require radical reconfigurations of historic spaces are inappropriate for the building.

2. Assemble a qualified team. This team ideally should consist of a preservation architect, mechanical engineer, electrical engineer, structural engineer, and preservation consultants, each knowledgeable in codes and local requirements. If a special use (church, museum, art studio) or a collection is involved, a specialist familiar with the mechanical requirements of that building type or collection should also be hired.

Team members should be familiar with the needs of historic buildings and be able to balance complex factors: the preservation of the historic architecture (aesthetics and conservation), requirements imposed by mechanical systems (quantified heating and cooling loads), building codes (health and safety), tenant requirements (quality of comfort, ease of operation), access (maintenance and future replacement), and the overall cost to the owner.

3. Undertake a condition assessment of the existing building and its systems. What are the existing construction materials and mechanical systems? What condition are they in and are they reusable? Where are existing chillers, boilers, air handlers, or cooling towers located? Look at the condition of all other services that may benefit from being integrated into a new system, such as electrical and fire suppression systems. Where can energy efficiency be improved to help downsize any new equipment added, and which of the historic features, e.g. shutters, awnings, skylights, can be reused? Evaluate air infiltration through the exterior envelope; monitor the interior for temperature and humidity levels with hygrometers for at least a year. Identify building, site, or equipment deficiencies or the presence of asbestos that must be corrected prior to the installation or upgrading of mechanical systems.

4. Prioritize architecturally significant spaces, finishes, and features to be preserved. Significant architectural spaces, finishes and features should be identified and evaluated at the outset to ensure their preservation. This includes significant existing mechanical systems or elements such as hot water radiators decorative grilles, elaborate switch-plates, and nonmechanical architectural features such as cupolas, transoms, or porches. Identify nonsignificant spaces where mechanical equipment can be placed and secondary spaces where equipment and distribution runs on both a horizontal and vertical basis can be located. Appropriate secondary spaces for housing equipment might include attics, basements, penthouses, mezzanines, false ceiling or floor cavities, vertical chases, stair towers, closets, or exterior below-grade vaults.

The flexible duct work, seen here, can be used to advantage in tight attic spaces. Photo: NPS files.

5. Become familiar with local building and fire codes. Owners or their representatives should meet early and often with local officials. Legal requirements should be checked; for example, can existing ductwork be reused or modified with dampers? Is asbestos abatement required? What are the energy, fire, and safety codes and standards in place, and how can they be met while maintaining the historic character of the building? How are fire separation walls and rated mechanical systems to be handled between multiple tenants? Is there a requirement for fresh air intake for stair towers that will affect the exterior appearance of the building? Many of the health, energy, and safety code requirements will influence decisions made for mechanical equipment for climate control. It is important to know what they are before the design phase begins.

6. Evaluate options for the type and size of systems. A matrix or feasibility studies should be developed to balance the benefits and drawbacks of various systems. Factors to consider include heating and/or cooling, fuel type, distribution system, control devices, generating equipment and accessories such as filtration, and humidification. What are the initial installation costs, projected fuel costs, long-term maintenance, and life-cycle costs of these components and systems? Are parts of an existing system being reused and upgraded? The benefits of added ventilation should not be overlooked. What are the tradeoffs between one large central system and multiple smaller systems? Should there be a forced air ducted system, a two-pipe fan coil system, or a combined water and air system? What space is available for the equipment and distribution system? Assess the fire risk levels of various fuels. Understand the advantages and disadvantages of the various types of mechanical systems available. Then evaluate each of these systems in light of the preservation objectives established during the design phase of planning.

Overview of HVAC Systems

Water Systems: Hydronic radiators, fan coil, or radiant pipes

Water systems are generally called hydronic and use a network of pipes to deliver water to hot water radiators, radiant pipes set in floors or fan coil cabinets which can give both heating and cooling. Boilers produce hot water or steam; chillers produce chilled water for use with fan coil units. Thermostats control the temperature by zone for radiators and radiant floors.

Fan coil units have individual controls. Radiant floors provide quiet, even heat, but are not common.

Advantages: Piped systems are generally easier to install in historic buildings because the pipes are smaller than ductwork.

Disadvantages: There is the risk, however, of hidden leaks in the wall or burst pipes in winter if boilers fail. Fan coil condensate pans can overflow if not properly maintained.

Fan coils may be noisy.

Hydronic Radiators

Radiators or baseboard radiators are looped together and are usually set under windows or along perimeter walls. New boilers and circulating pumps can upgrade older

A fan coil unit in the basement is feeding controlled air to a primary space upstairs.

systems. Most piping was cast iron although copper systems can be used if separately zoned. Modern cast iron baseboards and copper fin-tubes are available. Historic radiators can be reconditioned.

Photo: Courtesy, Karen Sweeney, Frank Lloyd Wright Home & Studio.

Fan Coil Units

Fan coil systems use terminal cabinets in each room serviced by 2, 3, or 4 pipes approximately 1 1/2" each in diameter. A fan blows air over the coils which are serviced by hot or chilled water. Each fan coil cabinet can be individually controlled. Four-pipe fan coils can provide both heating and cooling all year long. Most piping is steel. Non-cabinet units may be concealed in closets or custom cabinetry, such as benches, can be built.

Central Air Systems

The basic heating, ventilation and air conditioning (HVAC) system is all-air, single zone fan driven designed for low, medium or high pressure distribution. The system is composed of compressor drives, chillers, condensers, and furnace depending on whether the air is heated, chilled or both. Condensers, generally air cooled, are located outside. The ducts are sheet metal or flexible plastic and can be insulated. Fresh air can be circulated. Registers can be designed for ceilings, floors and walls. The system is controlled by thermostats; one per zone.

Advantages: Ducted systems offer a high level of control of interior temperature, humidity, and filtration. Zoned units can be relatively small and well concealed.

Disadvantages: The damage from installing a ducted system without adequate space can be serious for a historic building. Systems need constant balancing and can be noisy.

Basic HVAC

Most residential or small commercial systems will consist of a basic furnace with a cooling coil set in the unit and a refrigerant compressor or condenser located outside the building. Heating and cooling ductwork is usually shared. If sophisticated humidification and dehumidification is added to the basic HVAC system, a full climate control system results. This can often double the size of the equipment.

Basic Heat Pump/Air System

The heat pump is a basic HVAC system as described above except for the method of generating hot and cold air. The system operates on the basic refrigeration cycle where latent heat is extracted from the ambient air and is used to evaporate refrigerant vapor under pressure. Functions of the condenser and evaporator switch when heating is needed. Heat pumps, somewhat less efficient in cold climates, can be fitted with electric resistance coil.

Combined Air and Water Systems

These systems are popular for restoration work because they combine the ease of installation for the piped system with the performance and control of the ducted system. Smaller air handling units, not unlike fan coils, may be located throughout a building with service from a central boiler and chiller. In many cases the water is delivered from a central plant which services a complex of buildings.

This system overcomes the disadvantages of a central ducted system where there is not adequate horizontal or vertical runs for the ductwork. The equipment, being smaller, may also be quieter and cause less vibration. If only one air handler is being utilized for the building, it is possible to house all the equipment in a vault outside the building and send only conditioned air into the structure.

Advantages: flexibility for installation using greater piping runs with shorter ducted runs; Air handlers can fit into small spaces.

Disadvantages: piping areas may have undetected leaks; air handlers may be noisy.

Other System Components

Non-systems components should not be overlooked if they can make a building more comfortable without causing damage to the historic resource or its collection.

Advantages: components may provide acceptable levels of comfort without the need for an entire system.

Disadvantages: Spot heating, cooling and fluctuations in humidity may harm sensitive collections or furnishings. If an integrated system is desirable, components may provide only a temporary solution.

Portable Air Conditioning

Installing a fan (successfully concealed here) for increased ventilation can be a successful low-tech substitute for air conditioning. Photo: Courtesy, Shelburne Village.

Most individual air conditioners are set in windows or through exterior walls which can be visually as well as physically damaging to historic buildings. Newer portable air conditioners are available which sit in a room and exhaust directly to the exterior through a small slot created by a raised window sash.

Fans

Fans should be considered in most properties to improve ventilation. Fans can be located in attics, at the top of stairs, or in individual rooms. In moderate climates, fans may eliminate the need to install central air systems.

Dehumidifiers

For houses without central air handling systems, a dehumidifier can resolve problems in humid climates. Seasonal use of dehumidifiers can remove moisture from damp basements and reduce fungal growth.

Heaters

Portable radiant heaters, such as those with water and glycol, may provide temporary heat in buildings used infrequently or during systems breakdowns. Care should be taken not to create a fire hazard with improperly wired units.

Designing the New System

In designing a system, it is important to anticipate how it will be installed, how damage to historic materials can be minimized, and how visible the new mechanical system will be within the restored or rehabilitated spaces. Mechanical equipment space needs are often overwhelming; in some cases, it may be advantageous to look for locations outside of the building, including ground vaults, to house some of the equipment but only if there is no adverse impact to the historic landscape or adjacent archeological resources. Various means for reducing the heating and cooling loads (and thereby the size of the equipment) should be investigated. This might mean reducing slightly the comfort levels of the interior, increasing the number of climate control zones, or improving the energy efficiency of the building.

The following activities are suggested during the design phase of the new system:

1. Establish specific criteria for the new or upgraded mechanical system. New systems should be installed with a minimum of damage to the resource and should be visually compatible with the architecture of the building. They should be installed in a way that is easy to service, maintain, and upgrade in the future. There should be safety and backup monitors in place if buildings have collections, computer rooms, storage vaults or special conditions that need monitoring. The new systems should work within the structural limits of the historic building. They should produce no undue vibration, no undue noise, no dust or mold, and no excess moisture that could damage the historic building materials. If any equipment is to be located outside of the building, there should be no impact to the historic appearance of building or site, and there should be no impact on archeological resources.

2. Prioritize the requirements for the new climate control system. The use of the building will determine the level of interior comfort and climate control. Sometimes, various temperature zones may safely be created within a historic building. This zoned approach may be appropriate for buildings with specialized collections storage, for buildings with mixed uses, or for large buildings with different external exposures, occupancy patterns, and delivery schedules for controlled air. Special archives, storage vaults or computer rooms may need a completely different climate control from the rest of the building. Determine temperature and humidity levels for occupants and collections and ventilation requirements between differing zones. Establish if the system is to run 24 hours a day or only during operating or business hours. Determine what controls are optimum (manual, computer, preset automatic, or other). The size and location of the equipment to handle these different situations will ultimately affect the design of the overall system as well.

3. Minimize the impact of the new HVAC on the existing architecture. Design criteria for the new system should be based on the type of architecture of the historic resource. Consideration should be given as to whether or not the delivery system is visible or hidden. Utilitarian and industrial spaces may be capable of accepting a more visible and functional system. More formal, ornate spaces which may be part of an interpretive program may require a less visible or disguised system. A ducted system should be installed without ripping into or boxing out large sections of floors, walls, or ceilings. A wet pipe system should be installed so that hidden leaks will not damage important decorative finishes. In each case, not only the type of system (air, water, combination), but its distribution (duct, pipe) and delivery appearance (grilles, cabinets, or registers) must be evaluated. It may be necessary to use a combination of different

systems in order to preserve the historic building. Existing chases should be reused whenever possible.

4. Balance quantitative requirements and preservation objectives. The ideal system may not be achievable for each historic resource due to cost, space limitations, code requirements, or other factors beyond the owner's control. However, significant historic spaces, finishes, and features can be preserved in almost every case, even given these limitations. For example, if some ceiling areas must be slightly lowered to accommodate ductwork or piping, these should be in secondary areas away from decorative ceilings or tall windows. If modern fan coil terminal units are to be visible in historic spaces, consideration should be given to custom designing the cabinets or to using smaller units in more locations to diminish their impact. If grilles and registers are to be located in significant spaces, they should be designed to work within the geometry or placement of decorative elements. All new elements, such as ducts, registers, pipe-runs, and mechanical equipment should be installed in a reversible manner to be removed in the future without further damage to the building.

This radiator would be identified as a significant element of the interior. In any work to upgrade the mechanical system, it would be retained and preserved, even if non-functioning. Photo: NPS files.

Systems Performance and Maintenance

Once the system is installed, it will require routine maintenance and balancing to ensure that the proper performance levels are achieved. In some cases, extremely sophisticated, computerized systems have been developed to control interior climates, but these still need monitoring by trained staff.

A sprinkler system is unobtrusively placed behind a false cornice at the end of a corridor. Photo: NPS files.

If collection exhibits and archival storage are important to the resource, the climate control system will require constant monitoring and tuning. Backup systems are also needed to prevent damage when the main system is not working. The owner, manager, or chief of maintenance should be aware of all aspects of the new climate control system and have a plan of action before it is installed.

Regular training sessions on operating, monitoring, and maintaining the new system should be held for both curatorial and building maintenance staff. If there are curatorial reasons to maintain constant temperature or humidity levels, only individuals thoroughly trained in how the HVAC system operates should be able to adjust thermostats. Ill-informed and haphazard attempts to adjust comfort levels,

or to save energy over weekends and holidays, can cause great damage.

HVAC Dos and Don'ts

DOs:

- Use shutters, operable windows, porches, curtains, awnings, shade trees and other historically appropriate nonmechanical features of historic buildings to reduce the heating and cooling loads. Consider adding sensitively designed storm windows to existing historic windows.
- Retain or upgrade existing mechanical systems whenever possible: for example, reuse radiator systems with new boilers, upgrade ventilation within the building, install proper thermostats or humidistats.
- Improve energy efficiency of existing buildings by installing insulation in attics and basements. Add insulation and vapor barriers to exterior walls only when it can be done without further damage to the resource.
- In major spaces, retain decorative elements of the historic system whenever possible. This includes switch-plates, grilles and radiators. Be creative in adapting these features to work within the new or upgraded system.
- Use space in existing chases, closets or shafts for new distribution systems.
- Design climate control systems that are compatible with the architecture of the building: hidden system for formal spaces, more exposed systems possible in industrial or secondary spaces. In formal areas, avoid standard commercial registers and use custom slot registers or other less intrusive grilles.
- Size the system to work within the physical constraints of the building. Use multi-zoned smaller units in conjunction with existing vertical shafts, such as stacked closets, or consider locating equipment in vaults underground, if possible.
- Provide adequate ventilation to the mechanical rooms as well as to the entire building. Selectively install air intake grilles in less visible basement, attic, or rear areas.
- Maintain appropriate temperature and humidity levels to meet requirements without accelerating the deterioration of the historic building materials. Set up regular monitoring schedules.
- Design the system for maintenance access and for future systems replacement.
- For highly significant buildings, install safety monitors and backup features, such as double pans, moisture detectors, lined chases, and battery packs to avoid or detect leaks and other damage from system failures.

- Have a regular maintenance program to extend equipment life and to ensure proper performance.
- Train staff to monitor the operation of equipment and to act knowledgeably in emergencies or breakdowns.
- Have an emergency plan for both the building and any curatorial collections in case of serious malfunctions or breakdowns.

DON'TS:

- Don't install a new system if you don't need it.
- Don't switch to a new type of system (e.g. forced air) unless there is sufficient space for the new system or an appropriate place to put it.
- Don't over-design a new system. Don't add air conditioning or climate control if they are not absolutely necessary.
- Don't cut exterior historic building walls to add through-wall heating and air conditioning units. These are visually disfiguring, they destroy historic fabric, and condensation runoff from such units can further damage historic materials.
- Don't damage historic finishes, mask historic features, or alter historic spaces when installing new systems.
- Don't drop ceilings or bulkheads across window openings.
- Don't remove repairable historic windows or replace them with inappropriately designed thermal windows.
- Don't seal operable windows, unless part of a museum where air pollutants and dust are being controlled.
- Don't place condensers, solar panels, chimney stacks, vents or other equipment on visible portions of roofs or at significant locations on the site.
- Don't overload the building structure with the weight of new equipment, particularly in the attic.
- Don't place stress on historic building materials through the vibrations of the new equipment.
- Don't allow condensation on windows or within walls to rot or spall adjacent historic building materials.

Maintenance staff should learn how to operate, monitor, and maintain the mechanical equipment. They must know where the maintenance manuals are kept. Routine maintenance schedules must be developed for changing and cleaning filters, vents, and condensate pans to control fungus, mold, and other organisms that are dangerous to health. Such growths can harm both inhabitants and equipment. (In piped systems, for example, molds in condensate pans can block drainage lines and cause an overflow to leak onto finished surfaces). Maintenance staff should also be able to monitor the appropriate gauges, dials, and thermographs. Staff must be trained to intervene in emergencies, to know where the master controls are, and whom to call in an emergency. As new personnel are hired, they will also require maintenance training.

In addition to regular cyclical maintenance, thorough inspections should be undertaken from time to time to evaluate the continued performance of the climate control system. As the system ages, parts are likely to fail, and signs of trouble may appear. Inadequately ventilated areas may smell musty. Wall surfaces may show staining, wet patches, bubbling or other signs of moisture damage. Routine tests for air quality, humidity, and temperature should indicate if the system is performing properly. If there is damage as a result of the new system, it should be repaired immediately and then closely monitored to ensure complete repair.

Equipment must be accessible for maintenance and should be visible for easy inspection. Moreover, since mechanical systems last only 15-30 years, the system itself must be "reversible." That is, the system must be installed in such a way that later removal will not damage the building. In addition to servicing, the backup monitors that signal malfunctioning equipment must be routinely checked, adjusted, and maintained. Checklists should be developed to ensure that all aspects of routine maintenance are completed and that data is reported to the building manager.

Summary and References

The successful integration of new systems in historic buildings can be challenging. Meeting modern HVAC requirements for human comfort or installing controlled climates for museum collections or for the operation of complex computer equipment can result in both visual and physical damage to historic resources. Owners of historic buildings must be aware that the final result will involve balancing multiple needs; no perfect heating, ventilating, and air conditioning system exists. In undertaking changes to historic buildings, it is best to have the advice and input of trained professionals who can:

- assess the condition of the historic building,
- evaluate the significant elements that should be preserved or reused,
- prioritize the preservation objectives,
- understand the impact of new interior climate conditions on historic materials
- integrate preservation with mechanical and code requirements,

- maximize the advantages of various new or upgraded mechanical systems,
- understand the visual and physical impact of various installations,
- identify maintenance and monitoring requirements for new or upgraded systems, and
- plan for the future removal or replacement of the system.

Too often the presumed climate needs of the occupants or collections can be detrimental to the long-term preservation of the building. With a careful balance between the preservation needs of the building and the interior temperature and humidity needs of the occupants, a successful project can result.

Acknowledgements

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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), National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments to a broad public.

October 1991

Reading List

Banham, Reyner. *The Architecture of the Well-Tempered Environment*. London: The Architectural Press, 1969.

Burns, John A., AIA. *Energy Conserving Features Inherent in Older Homes*. Washington: U.S. Department of Housing and Urban Development and U.S. Department of the Interior, 1982.

Cowan, Henry J. *Science and Building: Structural and Environmental Design in the Nineteenth and Twentieth Centuries*. New York: John Wiley and Sons, 1978.

Ferguson, Eugene S. "An Historical Sketch of Central Heating: 1800-1860," in *Building Early America* (Charles Peterson, editor) Philadelphia: Chilton Book Co., 1976.

Fitch, James Marston. *American Building: The Environmental Forces That Shape It*. Boston: Houghton-Mifflin Co., 1972.

Giedion, Siegfried. *Mechanization Takes Command—a Contribution to Anonymous History*. New York: Oxford University Press, 1948.

Merritt, Frederick S. *Building Engineering and Systems Design*. New York: Van Nostrand Reinhold Co, 1979.

Smith, Baird M. *Preservation Briefs 3: Conserving Energy in Historic Buildings*. Washington, DC: U.S. Department of the Interior, 1978.

Turberg, Edward. *A History of American Building Technology*. Durham: Durham Technical Institute, 1981.

1.2.2.2 New ducts, grills, light fixtures, and switches (GSA 2016d)

U.S. General Services Administration

Guidelines For Locating New Ducts, Grilles, Light Fixtures And Switches In Historic Buildings

Procedure code:

1501003G

Source:

PrsrvtN Ntbk Series/Mech & Elec Systems For Historic Bldgs

Division:

Mechanical

Section:

Basic Mechanical Requirements

Last Modified:

08/05/2016

This standard includes general guidelines for locating new mechanical and/or electrical systems in historic buildings with minimal adverse impact on the building's appearance or character.

General:

- When possible, install new systems that are reversible.
- Reuse existing holes where possible.
- Use existing interstitial spaces to conceal systems.
- Conceal wiring when possible.

Ductwork:

- Conceal piping and ductwork as much as possible, but DO NOT install suspended ceiling systems to do so.
- If suspended ceiling systems must be installed, DO NOT allow system to abut glazing. The historic appearance of the window should be maintained where possible. This can be accomplished by "boxing" around window heads and leaving the complete window exposed to view.
- Where piping cannot be easily concealed by providing alternative routes through less significant spaces, provide gypsum board enclosures of the minimum size necessary to sufficiently conceal the pipes.
- Preserve ornamental walls and ceilings as much as possible. Avoid penetrating or attaching to ornamental finishes.
- Where possible, place pipes, conduit, etc. along recessed ledges or other areas of minimal visibility.
- Where possible use piping of minimum diameter for purposes specified.
- Paint pipes, conduit, etc. where possible to blend with adjacent finishes.

- Where possible, use decoration patterns to disguise new placement of wiring or systems.
- Conceal ductwork in unused closets when possible and provide adequate ventilation.
- Use an air-sampling system instead of a smoke detector when possible; only a small hole in the ceiling is required and very little space in the ceiling is required for the pipe.
- Conceal sprinkler heads and smoke detectors in decorative ,plaster ceilings.
- Use unused fireplaces for return air ducts.
- Use permanently placed furniture to disguise ductwork.

Grilles:

- Reuse original hardware, such as grilles, etc. where possible.
- Specify new grilles, light fixtures, etc. to match original as closely as possible, in material and pattern.
- If reuse of an existing grille is not possible, leave original grille in place and locate new grille within five feet of original location - preferably on a non-ornamental surface such as flat plaster.

Light Fixtures:

- Rewire, clean and refinish original fixtures when possible.
- NEVER attach fluorescent fixtures directly to ceiling medallions.
- Conceal the light source when installing indirect lighting.
- Introduce as few new fixtures and holes in the ceiling as possible.
- Provide emergency lighting that is as unobtrusive as possible; use a small fixture if possible; make sure the battery pack is concealed.
- Conceal ambient lighting behind ceiling moldings when possible.

Switches

- Conceal Conduit For Light Switches, Fire Alarms And Other Controls Behind Decorative Surfaces If Possible Rather Than Attaching It Onto The Surfaces.
- Paint Switch Plates And Access Panels Separately So They Can Be Easily Removed.
- Conceal Fire Alarm Equipment Behind Unused Heating Grilles.
- Use Wireless Fire Alarm Systems When Possible To Eliminate Unsightly Conduit And Wiring.
- Conceal Electrical Panelboards In Unused Closets When Possible And Provide Adequate Ventilation
- Conceal Smoke Detectors In Decorative Plaster Ceilings.

1.3 Preservation and rehabilitation guidelines for mechanical systems

According to *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*, the proper procedure for preservation and rehabilitation is to respect the significance of the original materials and features, repair and retain them wherever possible, and replace them only when absolutely necessary (Grimmer 2017) .

The following recommendations for care of historic mechanical systems are to be thoroughly read and understood before a treatment is specified.

Table 1 (preservation) and Table 2 (rehabilitation) contain information excerpted from Grimmer 2017. Any related NPS or GSA guidelines should also be consulted to determine the appropriateness of any treatment.

Table 1. Preservation treatment for mechanical systems and lighting (Grimmer 2017, 58–59).

Preservation Treatment for Mechanical Systems and Lighting	
RECOMMENDED	NOT RECOMMENDED
<i>Identifying, retaining, and preserving</i> visible features of early mechanical systems that are important in defining the overall historic character of the building, such as radiators, vents, fans, grilles, and plumbing and lighting fixtures.	Removing or altering visible features of mechanical systems that are important in defining the overall historic character of the building so that, as a result, the character is diminished.
<i>Stabilizing</i> functioning mechanical systems as a preliminary measure, when necessary, prior to undertaking preservation work.	Failing to stabilize a functioning mechanical system and its visible features until additional work is undertaken.
<i>Protecting and maintaining</i> functioning mechanical, plumbing, and electrical systems and their features through cyclical maintenance.	Failing to protect and maintain functioning mechanical, plumbing, and electrical systems on a cyclical basis so that their deterioration results.
Improving the energy efficiency of existing mechanical systems to help reduce the need for a new system by installing storm windows, insulating attics and crawl spaces, or adding awnings, if appropriate.	
Evaluating the overall condition of functioning mechanical systems to determine whether more than protection and maintenance, such as repairs to mechanical system components, will be necessary.	Failing to undertake adequate measures to ensure the protection of structural systems.
<i>Repairing</i> mechanical systems by augmenting or upgrading system components (such as installing new pipes and ducts), rewiring, or adding new compressors or boilers.	Replacing a mechanical system when its components could be upgraded and retained.
<i>The following work is highlighted to indicate that it represents the greatest degree of intervention generally recommended within the treatment Preservation, and should only be considered after protection, stabilization, and repair concerns have been addressed.</i>	
Limited Replacement in Kind	
<i>Replacing</i> in kind those extensively deteriorated or missing visible features of mechanical systems when there are surviving prototypes, such as ceiling fans, radiators, grilles, or lighting fixtures.	Installing a visible replacement feature that does not convey the same appearance.
<i>The following work should be considered in a Preservation project when the installation of new mechanical equipment or an entire system is required to make the building functional.</i>	
Installing a new mechanical system, if required, so that it results in the least alteration possible to the historic building and its character-defining features.	Installing a new mechanical system so that character-defining structural or interior features are radically changed, damaged, or destroyed.
Providing adequate structural support for new mechanical equipment.	Failing to consider the weight and design of new mechanical equipment so that, as a result, historic structural members or finished surfaces are weakened or cracked.
Installing new mechanical and electrical systems and ducts, pipes, and cables in closets, service areas, and wall cavities to preserve the historic character of the interior space.	Installing ducts, pipes, and cables where they will obscure character-defining features or negatively impact the historic character of the interior. Concealing mechanical equipment in walls or ceilings in a manner that results in extensive loss or damage or otherwise obscures historic building materials and character-defining features.

**Table 2. Rehabilitation treatment for mechanical systems and lighting
(Grimmer 2017, 125–127).**

Rehabilitation Treatment for Mechanical Systems and Lighting	
RECOMMENDED	NOT RECOMMENDED
<i>Identifying, retaining, and preserving</i> visible features of early mechanical systems that are important in defining the overall historic character of the building, such as radiators, vents, fans, grilles, and plumbing and lighting fixtures.	Removing or substantially changing visible features of mechanical systems that are important in defining the overall historic character of the building so that, as a result, the character is diminished.
<i>Protecting and maintaining</i> mechanical, plumbing, and electrical systems and their features through cyclical maintenance.	Failing to protect and maintain a functioning mechanical system, plumbing, and electrical systems and their visible features on a cyclical basis so that their deterioration results.
Improving the energy efficiency of existing mechanical systems to help reduce the need for a new system by installing storm windows, insulating attics and crawl spaces, or adding awnings, if appropriate.	
Evaluating the overall condition of mechanical systems to determine whether more than protection and maintenance, such as repairs to mechanical system components, will be necessary.	Failing to undertake adequate measures to ensure the protection of mechanical system components.
<i>Repairing</i> mechanical systems by augmenting or upgrading system components (such as installing new pipes and ducts), rewiring, or adding new compressors or boilers.	Replacing a mechanical system when its components could be upgraded and retained.
<i>Replacing</i> in kind or with a compatible substitute material those extensively deteriorated or missing visible features of mechanical systems when there are surviving prototypes, such as ceiling fans, radiators, grilles, or plumbing fixtures.	Installing a visible replacement feature of a mechanical system, if it is important in defining the historic character of the building, that does not convey the same appearance.
<i>The following work is highlighted to indicate that it is specific to Rehabilitation projects and should only be considered after the preservation concerns have been addressed.</i>	
Alterations and Additions for a New Use	
Installing a new mechanical system, if required, so that it results in the least alteration possible to the historic building and its character-defining features.	Installing a new mechanical system so that character-defining structural or interior features are radically changed, damaged, or destroyed.
Providing adequate structural support for the new mechanical equipment.	Failing to consider the weight and design of new mechanical equipment so that, as a result, historic structural members or finished surfaces are weakened or cracked.
Installing new mechanical and electrical systems and ducts, pipes, and cables in closets, service areas, and wall cavities to preserve the historic character of the interior space.	Installing systems and ducts, pipes, and cables in walls or ceilings in a manner that results in extensive loss or damage or otherwise obscures historic building materials and character-defining features.
Concealing HVAC ductwork in finished interior spaces, when possible, by installing it in secondary spaces (such as closets, attics, basements, or crawl spaces) or in appropriately-located, furred-down soffits.	Leaving HVAC ductwork exposed in most finished spaces or installing soffits in a location that will negatively impact the historic character of the interior or exterior of the building.
Installing exposed ductwork in a finished space when necessary to protect and preserve decorative or other features (such as column capitals, pressed-metal or ornamental plaster ceilings, coffers, or beams) that is painted, and appropriately located so that it will have minimal impact on the historic character of the space.	Installing exposed ductwork in a finished space when necessary to protect and preserve decorative or other features that is not painted, or is located where it will negatively impact the historic character of the space.
Lowering ceilings, installing a dropped ceiling, or constructing soffits to conceal ductwork in a finished space when this will not result in extensive loss or damage to historic materials or decorative and other features, and will not change the overall character of the space or the exterior appearance of the building (i.e., lowered ceilings or soffits visible through window glazing).	Lowering ceilings, installing a dropped ceiling, or constructing soffits to conceal ductwork in a finished space in a manner that results in extensive loss or damage to historic materials or decorative and other features, and will change the overall character of the space or the exterior appearance of the building.

(Table continues on next page.)

RECOMMENDED	NOT RECOMMENDED
Installing appropriately located, exposed ductwork in historically-unfinished interior spaces in industrial or utilitarian buildings.	
Installing a split system mechanical unit in a manner that will have minimal impact on the historic character of the interior and result in minimal loss of historic building material.	Installing a split system mechanical unit without considering its impact on the historic character of the interior or the potential loss of historic building material.
Installing heating or air conditioning window units only when the installation of any other system would result in significant damage or loss of historic materials or features.	
Installing mechanical equipment on the roof, when necessary, so that it is minimally visible to preserve the building's historic character and setting.	Installing mechanical equipment on the roof that is overly large or highly visible and negatively impacts the historic character of the building or setting.
Placing air conditioning compressors in a location on a secondary elevation of the historic building that is not highly visible.	Placing air conditioning compressors where they are highly visible and negatively impact the historic character of the building or setting.

1.4 Maintenance / management for mechanical systems

All building materials deteriorate with age and exposure to the weather. Through routine inspection and cyclical maintenance, the useful life span of a building and its historic fabric will be greatly increased. Preventive maintenance involves regular inspection of those parts of the building that are most likely to develop problems. Having a checklist for each USMMA building is advised to help the USMMA CRM and maintenance department identify and keep an accurate record or inventory of the building's problems, to facilitate systematic repair and maintenance. Begin early in project planning to ensure that design scopes, qualifications, and budgets address preservation compliance requirements.

Repair, renovation, and replacement of character-defining features to the contributing features to the USMMA historic district, such as historic mechanical systems (including lighting), **MUST** be coordinated with the NY SHPO. If a character-defining feature has been previously removed or replaced on the contributing building, prior to this report and as future renovations occur, these need to be replaced with elements that replicate the original character-defining features of that building. Historic photographs found in *Character-Defining Features of Contributing Buildings and Structures in the United States Merchant Marine Academy Historic District* report (Smith, Enscoe, and Adams, August 2014) will help guide this process in coordination with the NY SHPO. Begin early in project planning to ensure that design scopes, qualifications, and budgets address preservation compliance requirements.

Electrical – lighting

Existing historic fixtures may be retrofitted with compact fluorescent lamps, reflectors, light emitting diode (LED) and other light sources to increase light output and energy efficiency, if changes can be made without affecting the appearance of the fixture (refer to historic drawings that are available, as shown in Figure 27).

To ensure that preservation and performance expectations are met, specifications for historic lighting replication, modification, or supplementation need to include requirement for product data, sample review, and mock-up test installation (Alderson 2009). Any new supplementary lighting necessary to meet lighting requirements should be designed and placed inconspicuously to avoid detracting from the historic lighting and architecture.

Replace missing or severely damaged historic light fixtures in-kind or with fixtures that match the original in appearance and materials and fit replacement fixtures to the existing mounting location.

Figure 27. Example of reference for a historic photograph (left, USMMA DPW, 1919) to the current replacement fixture (right, ERDC-CERL, 2013).

Heating and air conditioning

- Improving the energy efficiency of existing mechanical systems to help reduce the need for elaborate new equipment.

- Repairing mechanical systems by augmenting or upgrading system parts, such as installing new pipes and ducts; rewiring; or adding new compressors or boilers (NPS 1995, 100).
- Replacing in-kind or with compatible substitute material, those visible features of mechanical systems that are either extensively deteriorated or are prototypes such as ceiling fans, switchplates, radiators, grilles, or plumbing features.
- Maintenance staff should learn how to operate, monitor, and maintain the mechanical equipment and should know where manuals are kept.
- Routine maintenance schedules must be developed for changing and cleaning filters, vents, and condensate pans to control fungus, mold, and other organisms that are dangerous to health.

References

- Alderson, Caroline. 2009. "Upgrading Historic Building Lighting." *Technical Preservation Guidelines*, April. Washington, DC: Center for Historic Buildings, Office of the Chief Architect, Public Buildings Service, U.S. General Services Administration. <https://www.gsa.gov/cdnstatic/TechnicalGuideLightingFINAL2.pdf>.
- Grimmer, Anne E. 2017. *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*. (Revised from 1995 work of same title by Kay D. Weeks and Anne E. Grimmer.) Washington, DC: U.S. Department of the Interior, National Park Service, Technical Preservation Services. <https://www.nps.gov/tps/standards/treatment-guidelines-2017.pdf>.
- GSA. 2016a. "Cleaning and Painting Cast Iron Lamps." Division: Electrical; Section: Lighting Fixtures; Procedure code: 1651005S. Washington, DC: U.S. General Services Administration. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88525.
- _____. 2016b. "Cleaning Ornamental Bronze Light Fixtures." Division: Electrical; Section: Lighting; Procedure code: 1651003S. Washington, DC: U.S. General Services Administration. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88418.
- _____. 2016c. "Restoring Original Wrought-Iron Wall Luminaries." Division: Electrical; Section: Lighting Fixtures; Procedure code: 1651001S. Washington, DC: U.S. General Services Administration. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88394.
- _____. 2016d. "Guidelines for Locating New Ducts, Grilles, Light Fixtures, and Switches in Historic Buildings." Division: Mechanical; Section: Basic Mechanical Requirements; Procedure code: 1501003G. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88461.
- _____. 2017a. "Sources of Historic Lighting Reproductions." Division: Electrical; Section: Lighting; Procedure code: 1650001R. Washington, DC: U.S. General Services Administration. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88317.
- _____. 2017b. "Replacing Ornamental Bronze Light Fixtures." Division: Electrical; Section: Lighting Fixtures; Procedure code: 1651002S. Washington, DC: U.S. General Services Administration. https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents?Form_Load=88541.

- NPS. 1995. *Standards with Rehabilitation and Guidelines for Rehabilitating Historic Buildings*. Online document posted by Pennsylvania Historical & Museum Commission at: <http://www.phmc.pa.gov/Preservation/About/Documents/standards-for-rehabilitation.pdf>.
- Park, Sharon C. 1991. *Heating, Ventilating, and Cooling Historic Buildings—Problems and Recommended Approaches*. Preservation Brief #24. Washington, DC: U.S. Department of the Interior, National Park Service, Technical Preservation Services. <https://www.nps.gov/tps/how-to-preserve/briefs/24-heat-vent-cool.htm>.
- Smith, Adam D., Susan I. Enscoe, and Sunny E. Adams. 2014. *Character-Defining Features of Contributing Buildings and Structures in the United States Merchant Marine Academy Historic District*. ERDC/CERL SR-14-5. Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Laboratory. <http://dx.doi.org/10.21079/11681/27476>.

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14. ABSTRACT The U.S. Merchant Marine Academy is located in Kings Point, New York. The Academy is listed on the National Register of Historic Places (#14000538). The historic district contains contributing mansions constructed during the Gold Coast Era and the Academy buildings constructed in 1942 to 1969. All buildings require regular planned maintenance and repair. The most notable cause of historic building element failure and/or decay is not because the historic building is old, but rather it is caused by an incorrect or inappropriate repair and/or basic neglect of the historic building fabric. This document is a maintenance manual compiled with as-is conditions of building materials at the Academy. The <i>Secretary of the Interior's Standards for the Treatment of Historic Properties on Preservation, Rehabilitation, and Repair</i> are discussed per material. This 8-volume report includes an overview volume plus volumes on each of the following elements: concrete, wood, brick, metal, roofing, stucco, and mechanical systems. All mentioned repair procedures are from the U.S. General Services Administration (GSA): Historic Preservation Technical Procedures and/or the National Park Service's series of Preservation Briefs. This report satisfies Section 110 of the National Historic Preservation Act (NHPA) of 1966, as amended.					
15. SUBJECT TERMS United States Merchant Marine Academy, Historic preservation, Historic districts, Cultural property, Historic buildings--Maintenance and repair					
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