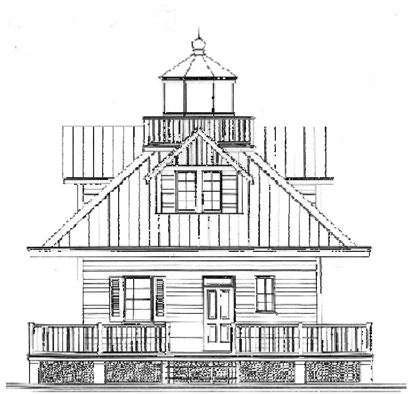
Historic Lighthouse Preservation Handbook



The Historic Lighthouse Preservation Handbook was created through a cooperative partnership between the National Park Service, U.S. Coast Guard, Department of Defense Legacy Resource Management Program, and U.S. Lighthouse Society. The 328-page preservation manual, released in August 1997, focuses primarily on the maintenance problems associated with the many different materials and construction techniques used in these unique structures. In addition to sections devoted to preservation treatments, it includes a brief history of the U.S. Lighthouse Service and lighthouse construction types; existing historic preservation laws, standards, and guidelines; case studies for both lighthouse rehabilitation and restoration projects; related activities (interpretation, funding, safety management, etc.); and sources for more information.

The treatment sections include data gathered from condition assessments and significance evaluations at 21 lighthouse sites around the country. The treatments encompass both protection and stabilization (mothballing) as well as repair. The Handbook is also based on information from applicable NPS publications, USCG files, and material generated by non-profit groups and museums. The Handbook's technical guidance was developed by the Service's Historic Preservation Training Center; the historical background was created largely through a cooperative agreement with the U.S. Lighthouse Society; and the overall production of the Handbook was coordinated by the NPS National Maritime Initiative.

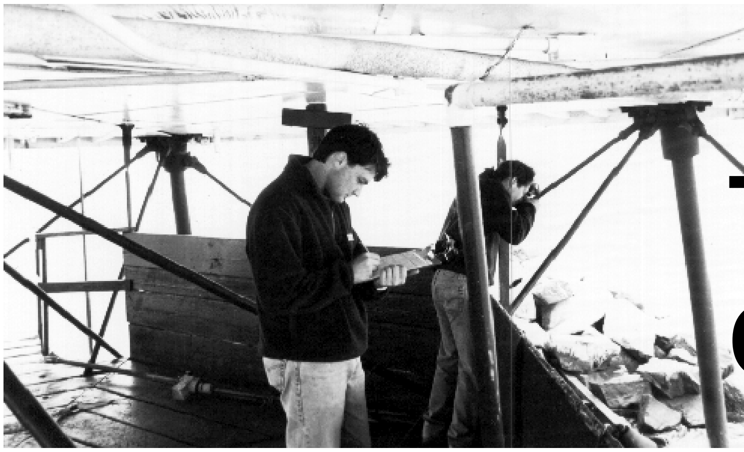


Table of Contents

Figure 1. Mike Seibert and Paul Neidinger of Williamsport Preservation Training Center perform a condition assessment of Thomas Point Shoals Light Station, Maryland, in 1995.

NMI photo

Introduction

Figure 1. Conducting a condition assessment at Cove Point Light Station, near Lusby, Maryland, in 1995.

The *Historic Lighthouse Preservation Handbook* was created through a cooperative partnership between the National Park Service (NPS), U.S. Coast Guard (USCG), and the Department of Defense (DoD). The *Handbook* addresses preservation issues related to historic lighthouses with an emphasis on the maintenance problems associated with the many different materials and construction techniques used in these unique structures. **Historic Lighthouse Preservation** (Part IV) includes data gathered from condition assessments and historic significance evaluations at 21 light stations around the country as well as information from applicable NPS guidance, USCG files, and material generated by non-profit groups, museums, and architectural and engineering firms. **Beyond Basic Preservation** (Part V) includes case studies reflecting lighthouse rehabilitation and restoration projects as well as related activities.

The *Handbook* is a compilation of lighthouse preservation issues, successful lighthouse maintenance solutions and lessons learned in lighthouse preservation procedures and techniques. The partners in the development of this *Handbook* recognize that the preservation of each lighthouse property must take into account its intended use, the resources available to the property owner or manager, and the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. The *Handbook* is intended to be used as a reference to identify lighthouse preservation needs and develop appropriate solutions. Use of this Handbook for regulatory or oversight purposes would not be appropriate.

Production of the *Handbook* has been coordinated by the National Maritime Initiative, a program within the NPS National Register, History, and Education Programs. Compilation of the technical sections was undertaken by the NPS Historic Preservation Training Center (formerly the Williamsport Preservation Training Center) with substantial support and assistance by the USCG. Other major portions were provided through a cooperative agreement with the U.S. Lighthouse Society.

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Note to Readers

The information presented in this *Handbook* is designed to be used by historic lighthouse managers as a reference to guide them through the process of preserving their historic lighthouse. Most sections are generally self-explanatory, however, Part IV., **Historic Lighthouse Preservation** may require some additional guidance to be used effectively.

The information in Part IV is designed to be referenced in either a general or a specific fashion. When planning a preservation treatment for a lighthouse, refer to the sections relating to the lighthouse construction material—masonry, iron, wood or concrete. In addition to information relating to treatments for each construction type, the text will guide you through an inspection procedure designed to identify potential problems associated with each. The inspection may indicate problems with components not specific to the construction type. For preservation treatments of these specific components refer to the sections on windows, doors, lanterns, interiors, and grounds.

Some information in each of the construction material sections appears to be repetitive; this is intentional. Although the material looks similar, it has been designed to include the specific details associated with each construction material. The intent of this organizational method is to provide "one stop shopping" for the lighthouse manager concerning his or her particular lighthouse. For example, the lighthouse manager responsible for a wood lighthouse may not be particularly concerned with the nuances of the preservation treatments required for a masonry lighthouse, and vice versa. This should not limit the *Handbook*, however, from being used as a general reference for historic lighthouse preservation.

As in any profession, the development of technology in the preservation field is continually evolving. A handbook of this type has inherent limitations and cannot be expected to be the complete and final authority on any matter. If when using this handbook questions arise that are beyond the scope of this document, it is strongly recommended that the advice of an experienced preservation professional is obtained.

Why Preserve Lighthouses?

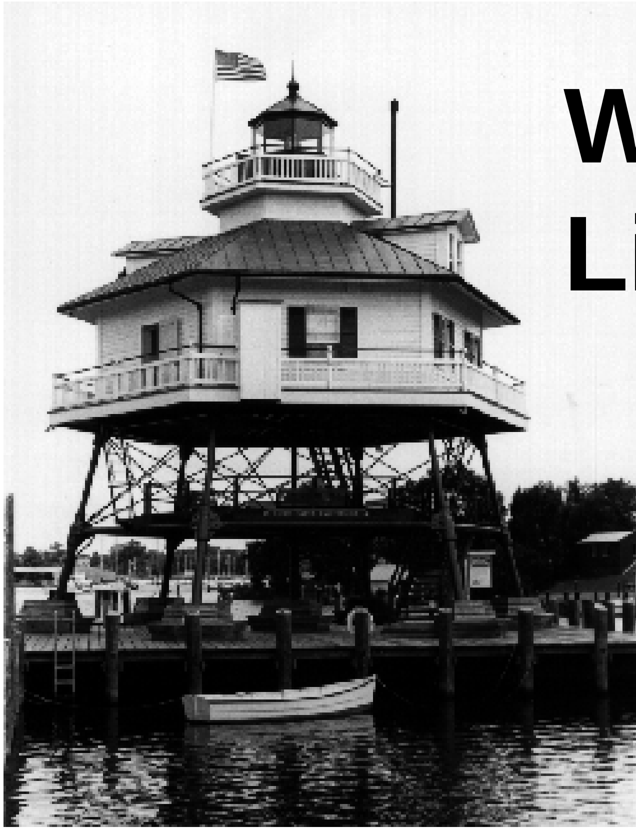
Calvert Marine Museum photo

Figure 1. Drum Point Lighthouse at Calvert Marine Museum in Solomons, Maryland.

What is a Lighthouse?

There is no standard definition of a "lighthouse." Webster's dictionary defines a lighthouse as "a tower or other lofty structure with a powerful light at the top, erected at some place important or dangerous to navigation to serve as a guide or warning to ships at night."[1] Samuel Johnson, author of the first modern dictionary in the English language, in 1755, defined a lighthouse as "a high building at the top of which lights are hung to guide ships at sea." Lighthouses, however, are not restricted to guiding ships at sea, but are located on any body of water where vessels are assisted by their presence. The U.S. Lighthouse Service in 1915 regarded lighthouses as "lights where resident keepers were employed."[2]

Today, under this last definition, very few lights would be classified as lighthouses: all but one are automated and do not require keepers. A lighted buoy, while an aid to navigation, is not considered a lighthouse, whereas all lighthouses serve or once served as aids to navigation. The U.S. Coast Guard maintains about 50,000 aids to navigation but less than 500 lighthouses (the official Coast Guard count as of July

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[1] The character of the light could be fixed or revolving a various speeds to create timed flashes to distinguish it from nearby lights. Tall towers were often painted with different colors and patterns called "daymarks" so they could be identified during daylight hours.

[2] Robert de Gast, *The Lighthouses of The Chesapeake* (Baltimore, Maryland, The Johns Hopkins University Press, 1973), p. viii; *United States Lighthouse Service 1915* (Washington, D.C., Government Printing Office, 1916), p. 18; and *Webster's New Twentieth Century Dictionary*, Second Edition (New York, New York, Simon and Schuster, 1982), p. 1047. There are instances of lighthouses which were built for land travel. The Atacoma Desert town of Pica, Chile, had a lighthouse to guide travelers at night to their springs.

1992 was 481;[3] the Initiative's light station database reported 425 Coast Guard-owned light stations in September 1996).

"Lighthouse" and "light" are often used synonymously, but in fact have distinct meanings. Lighthouses are structures or towers which were built in strategic locations to contain and elevate lights. Lights are the aid-to-navigation signals which mariners use for navigation. "Light station" refers not only to the lighthouse but to all the buildings at the installation supporting the lighthouse including keeper's quarters, oil house, fog signal building, cisterns, boathouse, workshop, etc.

Counting the number of lighthouses in the United States depends not only on the definition used, but also whether one station has more than one light tower. For example, Three Sisters Lights, Cape Cod, Massachusetts, consists of three separate towers. Cape Henry Light Station, Virginia, consists of an inactive older tower and a newer operational tower. The Cape Charles Lighthouse, Virginia, consisted of three towers built in different locations at different times; the first tower is now completely washed away, the second tower is in ruins in the surf, and the third tower is still operational. The National Park Service's *1994 Inventory of Historic Light Stations* contains 611 existing historic light stations encompassing 631 existing historic light towers. An appendix includes 190 sites or ruins in a preliminary listing of former stations.[4]

[3] "United States Coast Guard Lighthouse Policy Review" (enclosure 7 to Chapter 6 of COMDTINST M11011.9B dated July 27, 1992), p. 1; copy in files of National Maritime Initiative, National Park Service, Washington, D.C.

[4] Candace Clifford, *1994 Inventory of Historic Light Stations* (Washington, D.C., National Park Service, 1994), p. ix and xviii; and James Delgado and Kevin Foster, "Guidelines for Evaluating and Documenting Historic Aids to Navigation," National Register Bulletin #34 (Washington, D.C., National Park Service, Interagency Resources Division), p. 2. The number of light station sites in the Initiative's lighthouse database had grown to 282 at the time of publication.

Lighthouses and Our National Heritage

> *Nothing indicates the liberality, prosperity or intelligence of a nation more clearly than the facilities which it affords for the safe approach of the mariner to its shores.*
>
> —*Report of the Lighthouse Board*, 1868

Lighthouses have been a part of our nation from its inception. In 1789, after adopting the Constitution and the Bill of Rights, the First Congress of the United States created the Lighthouse Establishment (in the ninth law passed) to take over the operation of the 12 colonial lighthouses, (including Boston Harbor Lighthouse built in 1716, the first lighthouse established in what today is the United States), as well as to oversee the construction and operation of new lighthouses. The first public works project in the United States was the building of Cape Henry Lighthouse, lighted in 1792. President George Washington took a personal interest in the Cape Henry Lighthouse, approving the construction contracts and the appointment of its first keeper. Similarly, John Adams and Thomas Jefferson attended to similar lighthouse duties during their presidencies. The First Congress placed responsibility for aids to navigation within the Treasury Department, where Alexander Hamilton personally administered them for several years. The high level of attention given to lighthouses by the newly created nation was tied directly to its need for commerce and its desire to compete with other world powers. Lighthouses helped to instill confidence in ship captains as well as

Figure 2. Rock Harbor Light Station on Isle Royale, Michigan, is one of 409 light stations listed in the National Register of Historic Places up through 1996.

foreign governments, symbolically implying that the United States was a responsible world power worthy of due recognition. Today the United States has the largest number of lighthouses as well as the most architecturally diverse, of any country in the world.[5]

By preserving light stations, we preserve for everyone a symbol of that chapter in American history when maritime traffic was the lifeblood of the nation, tying isolated coastal towns and headlands through trade to distant ports of the world.[6] Historic and cultural resources represent our nation's patrimony. The federal government has been turning over many lighthouses by lease, license, or sale to federally recognized non-profit organizations whose mission, at least in part, is to preserve the lighthouse. As stewards for their lighthouses, these organizations have certain responsibilities for proper maintenance and preservation and are expected to carry out these duties for the benefit of citizens both at local and national levels. The continued use and appreciation of these historic light stations is not merely in the interest of historic preservation groups but of the public at large. Each lighthouse is unique in the context of its geographic location, architectural style, and history. Even lighthouses which were sold by the government into private hands will benefit by good stewardship if for no other reason than to maintain their resale value. Where the historic integrity of the light station remains intact, the visitor can experience an important aspect of our maritime heritage.

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[5] Clifford, p. ix.

[6] Deborah Davis, "Keeping the Light: A Handbook for Adaptive Re-use of Island Lighthouse Stations" (Rockland, Maine, Island Institute, 1987), p. 2.

What Makes a Lighthouse "Historic?"

The National Register of Historic Places is considered the "official list of the Nation's cultural resources worthy of preservation." Authorized by the National Historic Preservation Act, the National Register is maintained by the Department of Interior's National Park Service. It is currently a listing of over 60,000 properties that have been nominated and accepted as having historic, architectural, archeological, engineering, or cultural significance, at the national, state, or local level. The nominations are maintained both on paper and in a computerized database. Nearly 70 percent of all lighthouses in the United States over 50 years old are either listed in the National Register or are determined eligible for listing, and the number is climbing as additional lighthouses are added to the list.

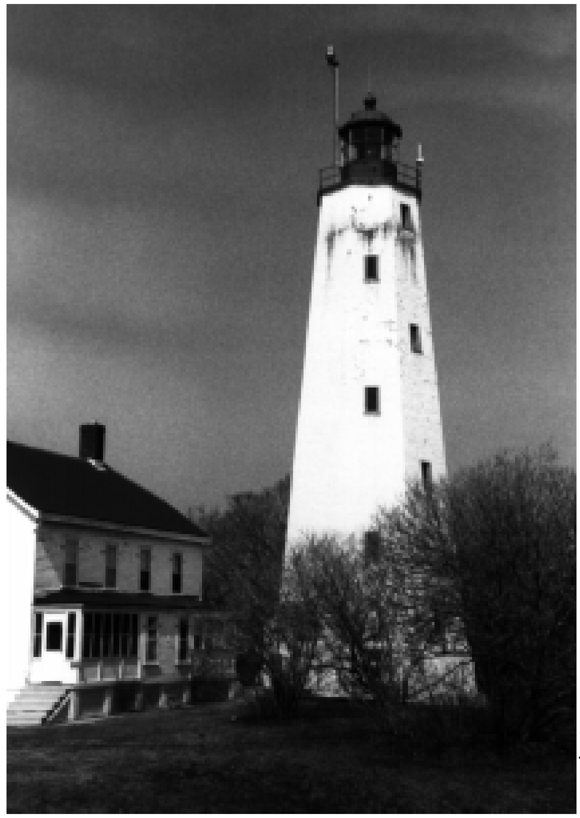

NMI photo

Figure 3. Sandy Hook Light Station, Highlands, New Jersey, is the oldest operating lighthouse in the U.S., making it significant for its role in American history.

Identifying Historic Properties

Not all light stations are necessarily historic nor do all warrant preservation. But how does one determine historic significance of light station properties? How can one be certain that a light station or portion of a light station (only one or more structures of a light station versus the entire light station) warrant preservation? Perhaps the best method for determination is using the criteria established by the federal government for inclusion of historic properties in the National Register of Historic Places.

These criteria include:

- significance of a property in American history
- significance of a property in American architecture
- significance of a property in American archeology
- significance of a property in American engineering
- significance of a property in American culture

The National Register nomination process uses the following criteria to determine the historic significance of sites, buildings, structures, and objects:

a) association with *events* that have made a significant contribution to the broad pattern of our history; or

b) association with the lives of *persons* significant in our past; or

c) embody the *distinctive characteristics* of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

d) have yielded, or may be likely to yield, *information* important in prehistory or history.

Besides meeting one or more of the National Register criteria, a property generally must also be at least 50 years old (exceptions are possible), and have integrity of location, design, setting, materials, workmanship, feeling, and association in order to be eligible for inclusion in the National Register. This means, in effect, that if a property has been seriously compromised by unsympathetic alterations, it may not be eligible for the National Register. Your State Historic Preservation Officer (see Part VI., **Resources** for listing) can assist you in determining whether your property is historically significant and whether or not it may qualify for listing in the National Register of Historic Places.

Examples of light stations which meet one or more of the National Register criteria:

- Cape Henry (first tower) Lighthouse, Virginia, first lighthouse built by United States Government and first public works project is significant for its role in American history.
- Thomas Point Shoals Light Station, Maryland, built in 1875, is the last largely unaltered spider-foundation cottage-type screwpile lighthouse in the United States. As such, it is significant for American architecture and engineering.
- Minots Ledge Light Station, Massachusetts, built in 1860, was the first, and most exposed wave-swept lighthouse built in the United States and is considered one of the top ten engineering feats of the U.S. Lighthouse Service. It is also significant for American engineering.
- Sandy Hook Lighthouse, New Jersey, built in 1764, is oldest extant lighthouse in United States. As such, it is a significant property in American history.
- Pooles Island Light Station fog-signal building, Maryland, built in 1825, now demolished with its foundation ruins eroding from the banks of the island, was the site of one of the earliest mechanized fog signal stations in the United States. It is a significant property in American archeology.

Benefits of Listing in the National Register of Historic Places

A federally owned lighthouse or any associated structures such as keeper's quarters, fog signal building, oil house, etc., which are listed or eligible for listing in the National Register of Historic Places, cannot be altered, neglected, or demolished without the federal agency going through the Section 106 process discussed later in this section.

For profit-making organizations, certain tax credits are available to the owner for restoration costs. For non-profit historical societies and preservation groups, listing on the National Register can provide the following benefits;

- distinguishing the property as having historical significance recognized by the United States Government;
- providing leverage for assisting the owner in raising preservation and maintenance funds directly related to the lighthouse and light station associated buildings; and
- making the project eligible for matching federal historic preservation funds passed through each state. These funds are made available through a competitive grant application process and have certain conditions. Check with your State Historic Preservation Office for more information (see Part VI for listing of SHPOs).

Federal agencies, through compliance with federal historic preservation requirements, play a leadership role in preserving our nation’s light stations. Most light stations are still under federal control, whether through the U.S. Coast Guard, Department of the Interior, Bureau of Land Management, or Department of Defense.

Federal Agency Responsibilities: The *National Historic Preservation Act of 1966*

In order to preserve our nation's heritage, a number of laws have been passed at the federal, state, and local levels to ensure that historic resources are recognized and taken into consideration during any public planning effort. While federal preservation laws date to 1906, the most prominent federal cultural resource law, from which most of the current laws, regulations, and guidelines stem, is the *National Historic Preservation Act of 1966, as amended*.

Section 106 of the *National Historic Preservation Act* (NHPA) requires a federal agency head with jurisdiction over a federal, federally assisted, or federally licensed undertaking, to take into account the effects of the agency's undertakings on *all* properties included in or eligible for inclusion in the National Register of Historic Places and, before approval of an undertaking, to afford the Advisory Council on Historic Preservation (ACHP or Advisory Council) a reasonable opportunity to comment on the undertaking.

Section 110: The intent of Section 110 is to ensure that historic preservation is fully integrated into the ongoing programs, review of agency procedures, and missions of federal agencies. The more important and appropriate portions of Section 110 which may apply to lighthouses are summarized below:

Section 110(a)(1) requires that before acquiring, constructing, or leasing buildings for purposes of carrying out agency responsibilities, all federal agencies will use, to the maximum extent feasible, historic properties available to the agency. This requires agencies to give priority to the use not only of historic properties that they own or control, but to any such properties that are available to the agency. Available historic properties might include those available for lease, purchase, or exchange. This section also designated the *Secretary of Interior's Standards and Guidelines for Archeology and Historic Preservation* as the specific professional standards to be followed. Section 110 and the Secretary's Standards also refer to the more specific standards, *Secretary of the Interior's Standards for Rehabilitation and Illustrated Guidelines for Rehabilitating Historic Buildings* (1992).

Section 110(b) requires each federal agency to "initiate measures to assure that where, as a result of federal action or assistance . . . an historic property is to be substantially altered or demolished, timely steps are taken to make or have made appropriate records, and that such records then be deposited . . . in the Library of Congress or with some other appropriate agency as may be designated by the Secretary [of the Interior], for future use and reference."

Section 110 Guidelines (53 FR 4727-46) state that "agencies should determine whether recordation is needed, and if so, the appropriate level and kind of recordation necessary, . . . in consultation with the State Historic Preservation Officer (SHPO), Advisory Council, and other concerned parties under 36 CFR Part 800 . . . The level and kind of documentation required . . . vary depending on the nature of the property, its relative significance . . . and the nature of the undertaking's effects."

These requirements put the obligations of compliance on the federal agencies, not the SHPO, the Advisory Council, or anyone else. To meet the regulations of the National Historic Preservation Act, a federal agency should:

- Minimize the risk of foreclosure by initiating Section 106 review as early as possible in the planning process.
- *Always* get Section 106 done before a final decision is made about whether to proceed with the project, before funds are spent on things such as advanced design, or purchase of materials, and if possible before those involved become fixed on a single preferred alternative.
- When working on the annual budget, it is important to think about compliance needs and advise supervisors on these budget matters. Although NHPA does not provide appropriation, Section 110(g) authorizes expenditure of project and program funds to support preservation work, such as compliance with Section 106 and doing work called for in a Memorandum of Agreement (MOA). It is necessary to meet compliance requirements through the normal budget process. Thinking of compliance needs while putting together installation's budgets can avoid funding delays later.
- Consider effects not only on properties already included on the National Register, but *also eligible properties*. It is the responsibility of the federal agency to ensure that eligible properties are identified, evaluated, and considered. These determinations of eligibility are made solely on historical, architectural, or cultural significance of a property, not management or mission requirements.

Failure to comply with preservation law may result in litigation or stop-work orders which delay completion of projects and escalate project costs.

Other federal laws which may affect lighthouse preservation and management include:

- *Antiquities Act*, 16 U.S.C.§§ 431-433
- *Archaeological and Historic Preservation Act*, 16 U.S.C. §§ 469-469c
- *Architectural Barriers Act*, 42 U.S.C.§§ 4151-4157
- *Historic Sites Act*, 16 U.S.C.§§ 461-467
- *National Environmental Policy Act*, 42 U.S.C.§§ 4321-4370c
- *National Historic Preservation Act*, 16 U.S.C.§§ 470-470w-6
- *Executive Order No. 11593*, Protection and Enhancement of the Cultural Environment, 36 Fed. Reg. 8921 (1971), reprinted in 16 U.S.C.§ 470 note

A summary of these laws is found in Part VI., **Resources**. Commanding officers and other personnel who deal or may deal with cultural resource management are responsible for knowing the laws and complying with these requirements. The best guide to these laws is *Introduction to Federal Projects and Historic Preservation Law* prepared by the Advisory Council on Historic Preservation and the General Services Administration Interagency Training Center. It is full of case studies and explains how these laws and regulations affect operations. A copy of this manual can be obtained from either agency. It is highly recommended as a useful shelf tool. *Federal Historic Preservation Laws* (1993), published by the National Park Service, Cultural Resources Programs, is another useful guide to these laws.

History of the Lighthouse Service and Lighthouse Construction Types

National Archives photo

Figure 1. Assembly of Point No Point Lighthouse caisson at Solomons, Maryland, before being transported to site in Chesapeake Bay.

History of the Lighthouse Service

The U.S. Lighthouse Establishment was created by the First Congress in 1789 to manage the twelve colonial lighthouses now controlled by the federal government and to oversee construction of new lighthouses. Sandy Hook Lighthouse, built in New Jersey in 1764, is the only colonial lighthouse that has survived (Boston Harbor Lighthouse, built in 1716, was rebuilt in 1783-1784). Colonial lighthouses were usually constructed of wood or rubble stone. Between 1789 and 1820 about 40 new lighthouses were built by the Lighthouse Establishment, many using brick and cut stone. Of these, only a few have survived, including Portland Head Lighthouse, Maine, built in 1790 and Cape Henry Lighthouse, Virginia, built in 1792. From 1820 until 1852, Steven Pleasonton, Fifth Auditor of the Treasury, was responsible for lighthouse construction and repairs. Though Pleasonton routinely returned unspent funds to the Treasury, during his tenure approximately 300 lighthouses were built. In 1847 the responsibility for the construction of six lighthouses was granted to the Army Corps of Engineers.

On August 31, 1852, the U.S. Lighthouse Establishment became the U.S. Lighthouse Board, largely as the result of numerous complaints about the state of the U.S. lighthouse system. The nine-member board was composed primarily of Naval and Army engineer officers. The country was divided into 12 new lighthouse districts, each with an inspector responsible for overall construction, maintenance, and purchasing. Over the next five decades several advances in lighthouse construction technology took place, including the development of exposed screwpile lighthouses, skeleton tower lighthouses, wave-swept interlocking stone lighthouses, iron caisson lighthouses, and breakwater lighthouses. Many examples of these lighthouses exist today. In 1886, the lighthouse districts were increased to 16.

The Lighthouse Board was transferred to the Department of Commerce and Labor on July 1, 1903. On June 17, 1910, the Lighthouse Board became the Bureau of Lighthouses. The number of districts increased to 19. Just before this transition, reinforced concrete lighthouse towers came into use, particularly along the west coast where earthquakes were common. In 1913 the Bureau was assigned to the Department of Commerce when it separated from the Department of Labor. In 1939 the Bureau was abolished and its functions transferred to the U.S. Coast Guard where the responsibility remains today.

At the end of World War II the Coast Guard staffed 468 light stations. Following the war, the Coast Guard embarked on a program of automation. The rationale for this program was 1) to reduce the cost of maintaining lighthouses, 2) to remove personnel from extremely isolated and hazardous locations, and 3) to make billets available for reprogramming. Despite these efforts, the Coast Guard 'manned' 327 lighthouses in 1962. The Coast Guard initiated the Lighthouse Automation and Modernization Program (LAMP) in 1968. LAMP was designed to accelerate and standardize the remaining lighthouses for automation and to standardize the equipment at those previously automated. Over $26 million was spent on LAMP over 20 years; 1989 was the last year for LAMP funding though a few automations were completed as late as fiscal year 1990. LAMP resulted in over 300 billet reductions amounting to savings in excess of $63 million, and recurring savings of about $7 million annually.[1] Every Coast Guard-owned lighthouse in the United States is now automated and unmanned, with the sole exception of Boston Lighthouse. It will continue to be staffed in accordance with Section 221 of the Coast Guard Authorization Act of 1989 (P.L. 101-225). The Coast Guard continues to use the living quarters of several former light stations as housing units for its personnel.

Lighthouse towers themselves have become less valuable to the Coast Guard because, with modern automated beacons, it is more cost effective to construct and maintain an aid to navigation on a steel structure or buoy, rather than inside the lantern of a traditional lighthouse tower. Thus, in many locations, the traditional lighthouse tower has been found to have little value to the U.S. Coast Guard mission, other than to provide a visual aid to mariners during daylight and good weather.[2]

The lighthouse automation process resulted in a loss of practical experience gained by personnel stationed at the lighthouses. The peculiarities and unique needs of the station could no longer be cared for on a daily basis. Experience and traditions were no longer passed on from one keeper to another. Many stations, especially the more remote ones, are seldom visited by Coast Guard personnel, as little as once or twice a year. The lack of simple maintenance such as mopping up condensation on a daily or weekly basis from the inside of the storm pane astragals of the lantern room now result in rust and corrosion. A broken storm pane (window), formerly replaced within a matter of hours, now may result in bird and rodent infestation. Vandalism from lack of on-site supervision and security is an even worse problem.

[1] "United States Coast Guard Lighthouse Policy Review" (enclosure 7 to Chapter 6 of COMDTINST M11011.9B dated July 27, 1992), pp. 5-6, copy in files of National Maritime Initiative, National Park Service, Washington, D.C.

[2] David Reese and Robert Browning, "Lighthouse Management:: A Balancing Act for the U.S. Coast Guard," *Cultural Resource Management* (June 1997).

NMI photo

Figure 2. Portland Head Light Station, Cape Elizabeth, Maine, one of the few remaining towers built by the Lighthouse Establishment between 1789 and 1820.

Lighthouse Construction Types[3]

Politics, need, cost, location, and geography of the site, as well as technology available at the time of construction influenced lighthouse designs. Before the mid-nineteenth century, lighthouse construction technology required solid rock or other stable foundation soils; onshore towers sometimes proved inadequate to warn of a shoal located offshore. In some locations a lighted buoy or a lightship[4] solved this problem. Riverine and estuarine environments, however, often had unstable muddy and/or sandy bottoms which could not support the heavy masonry towers then in vogue. In areas such as the Chesapeake Bay, Delaware Bay, the Gulf of Mexico, the Mississippi River delta, and the coral reefs of the Florida Keys, the development of newer technology using screwpile, caisson, and skeletal tower lighthouse construction was essential to adequately light these marine hazards.

As technology advanced, stations were improved or even moved to better mark hazards such as offshore shoals. The 95-foot-tall tower at Cape Hatteras Lighthouse (1803), North Carolina, was raised to 150 feet in 1854, and the present 208-foot tall tower replaced it in 1870.[5] The first Thomas Point Shoals Lighthouse (1825), Maryland, was a stone tower built on shore; it was replaced by an offshore screwpile

[3] The following section is from Ralph Eshelman, "American Lighthouse Construction Types," part of the draft Maritime Heritage of the United States National Historic Landmark Theme Context Study for Lighthouses, National Maritime Initiative, National Park Service, 1995.

[4] Lightships are a relatively new type of aid to navigation, first appearing in the U.S. in 1820. None are in operational use today. Lightships, however, played an important role in establishing light stations in locations difficult or impossible for the construction of submarine lighthouse structures.

[5] According to 1989 HABS documentation, the overall height of the structure is 208 feet including the foundation. The height from ground level was recorded at 197 feet.

structure in 1875 to place the aid closer to the navigation channel.[6]

Generally, coastal lighthouses on the low, flat southeastern coast of the United States tended to have tall towers to elevate the lens high enough so the light may be seen many miles at sea; whereas lighthouses on the west coast tended to have short towers built on sea cliffs high enough to project the light many miles at sea. Several light stations on the northeastern coast were also located to take advantage of naturally high elevation sites, such as Block Island Southeast Lighthouse, Rhode Island, and Monhegan Island Lighthouse, Maine. Ironically, the low clouds so characteristic of the west coast caused some station sites at high elevations to be moved to lower altitudes with taller towers in order to get the light below the low cloud levels, but high enough to be visible to ships at sea. The first Point Loma Lighthouse (1855) California tower was only 40 feet tall but was located on a bluff providing a focal plane of 462 feet above the water. It was replaced in 1891 by a 70-foot-high tower built at the base of the bluff with a focal plane of 88 feet above the water.[7]

Lighthouses were made from a variety of materials including wood, stone, brick, reinforced concrete, iron, steel, and even aluminum and fiberglass. Lighthouses were built on land, in the water, on islands, on top of ledges and cliffs, on breakwaters and piers, on caissons, and at least five are on fort walls. Some light towers are stand-alone structures, while others are attached or integral to the keeper's quarters or fog signal building.

The tower served principally as a support for the lantern which housed the optic. The lantern was typically constructed of cast iron; round, square, octagonal, or hexagonal-shaped, and surrounded by a stone or cast-iron gallery. Access to the lantern room was via stone, wood, or cast-iron stairs which either wound around a central column or spiraled along the interior sides of the tower walls.

Until the adoption of the Fresnel lens in the United States in the 1850s, there was no uniform design for the lantern. Pre-1850s lanterns are rare and are often referred to as "old style" or "bird cage" lanterns because of their bird cage appearance. Selkirk (Salmon River) Lighthouse, New York, built in 1838, retains its bird cage lantern. The "bird cage" lantern on Cape Henry Lighthouse, Virginia, is a reconstruction of one built in 1792. Many pre-1850s light towers had their older lantern removed and new cast-iron lanterns installed when Fresnel lenses were added to a light station; most light stations in the United States were fitted with Fresnel lenses by 1860. In addition to the replacement of the lantern, the tower supporting the lantern was often modified to accommodate the larger lenses.

Fresnel lenses were developed in seven standard sizes, depending on need. The largest first-order lenses were designed for important coastal sites while the sixth order, the smallest, was designed for small harbors and rivers (the seventh size was a third-and-one-half order). The meso radial and hyper radial were two additional lens sizes that were not used in the U.S. with the one exception, Makapuu Light, Hawaii. To accommodate these new lenses the Lighthouse Board designed four pre-made ready-to-assemble cast-iron lanterns for first, second, third, and fourth orders. (The fourth-order lantern could be used to

[6] Robert de Gast, *Lighthouses of Chesapeake Bay* (Baltimore: Johns Hopkins University Press, 1973) p. 79; F. Ross Holland, Jr., *Great American Lighthouses* (Washington D.C., Preservation Press, National Trust for Historic Preservation, 1994), p. 19; and Candace Clifford, *1994 Inventory of Historic Light Stations* (Washington, D.C., History Division National Park Service, 1994), p. 260.

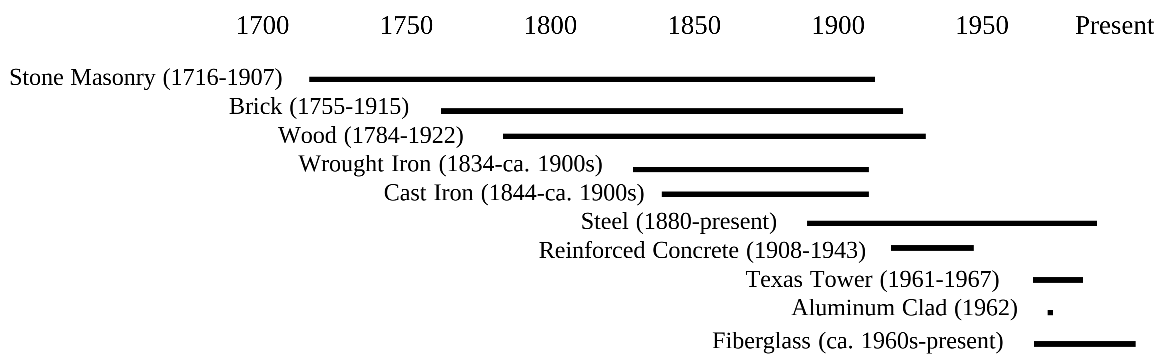
[7] Clifford, pp. 19-20.

accommodate the fourth-, fifth-, and sixth-order Fresnel lenses.) While it was possible to install a smaller order lens in a lantern of a larger order, it was not possible to increase the lens size for a lantern of a lesser order except for the fifth or sixth. Detailed plans for these cast-iron lanterns are available at the National Archives as well as plans for many other lanterns–often the exact plan for the lantern of a specific lighthouse.

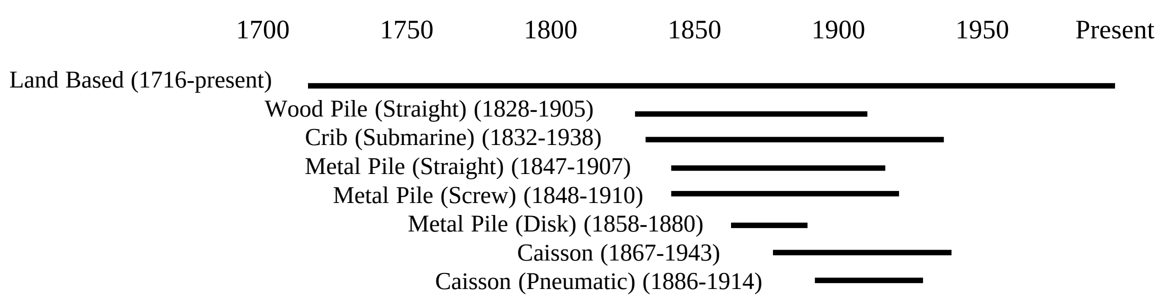
Windows in the tower were positioned to provide daylight onto the stairs. For taller towers, landings were provided at regular intervals. The top landing ended at the watch room where the keeper on duty ensured that the light was functioning properly. The lantern room above was usually reached via a ladder.

In addition to a light tower, a completely equipped light station on land often consisted of a keeper's quarters, oil house, fog-signal building, workshop, water supply, privy, landing wharf, boathouse and ways, barn, roads, walks, and fences. Some regions required special structures to aid in the operation of the lighthouse. The elevated walkway or "catwalk" found on some of the piers of the Great Lakes was necessary for the keeper to get to the light during severe storms when waves washed over the pier or ice made it too dangerous to walk on the pier. These "catwalks" are significant components of this type of light station and contribute to its historic integrity.

Tower Construction Types—Period of Construction



Tower Foundation Types—Period of Construction



SIDEBAR: Lighthouse Construction Types

Most lighthouses can be categorized by construction method, shape, building material, or foundation types. The lighthouse type can also be classified as terrestrial or aquatic, i.e., onshore or offshore types. The major construction types for historic lighthouses are wooden, masonry, wave-swept, concrete, cast-iron plate, skeletal, straightpile, screwpile, crib, caisson, and Texas tower.

Wooden tower: Most early wooden towers have burned and/or been replaced. Prospect Harbor Lighthouse (1891), Maine, is a good example of a stand-alone, conical wooden light tower. Plymouth/ Gurnet Point Light (1843), Massachusetts is the earliest surviving wooden tower.

NMI photo

Figure 3. Gurnet Point Lighthouse, wooden tower near Plymouth, Massachusetts.

NMI photo

Figure 4. Cape Henry Light Station, cast-iron tower, Fort Story, Virginia.

Masonry tower: Masonry towers were constructed of rubble stone, cut stone (dressed stone), or brick. The oldest standing masonry light tower in the United States is the 85-foot-tall Sandy Hook Lighthouse (1764), New Jersey, built of cut stone. Towers over 150 feet in height are referred to as tall towers. The 208-foot Cape Hatteras Lighthouse (1870), North Carolina, is the tallest lighthouse in the United States.

Wave-swept tower: Wave-swept lighthouses were built on low rocks or submarine ledges and constructed of interlocking stones to withstand the fury and power of waves in heavy seas. One of the first wave-swept towers built in the United States was the 114-foot Minot's Ledge Lighthouse (1860) offshore in

Massachusetts, which replaced a pile-type lighthouse that was destroyed by a storm. It was considered the "most important engineering work" constructed by the Lighthouse Board at the time.

Concrete tower: Concrete towers began to replace brick masonry towers at the beginning of the 20th century; a tower of *reinforced concrete* was first used in the United States at the 115-foot-tall Point Arena Lighthouse (1908), California.

Cast-iron-plate tower: Cast iron was lighter than stone or brick, relatively inexpensive, strong, watertight, and had a slow rate of deterioration. The second Cape Henry Lighthouse (1881), Virginia, is the tallest cast-iron-plate tower in the United States at 163 feet. Steel and wrought-iron plate was also sometimes used. This construction type was capable of being dismantled and moved; examples include Cape Canaveral, Florida and Hunting Island, South Carolina.

Skeletal tower: Onshore skeletal towers were built of metal and were typically constructed on concrete foundations. Offshore skeletal towers were also built of metal and typically constructed with straight or screwpile foundations (discussed below). Manitou Island Lighthouse (1861) and Whitefish Point Lighthouse (1861), Michigan, both built from the same plan, are the earliest onshore skeletal towers built in the United States. Like the cast-iron-plate tower, skeletal towers could also be dismantled and moved.

Straightpile: The pile foundation lighthouse utilized the principle of least resistance. Waves would pass through rather than crash against the foundation. This design of lighthouse structure was used offshore, even in wave-swept

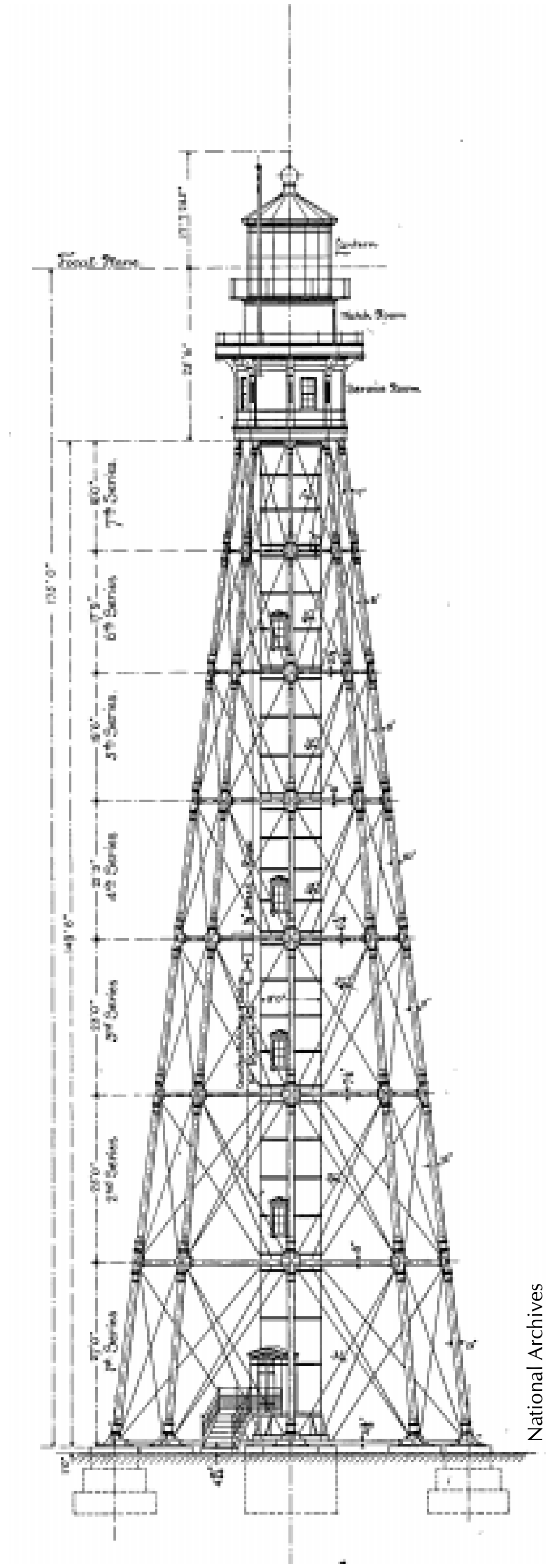


Figure 5. Construction drawing for Cape Charles Lighthouse, Virginia, an onshore skeletal tower.

Figure 6. Thomas Point Shoals Lighthouse with screwpile foundation located in Maryland's Chesapeake Bay; shown here in 1885.

Figure 7. Sabine Bank Lighthouse with caisson foundation in Texas.

locations. The earliest surviving straightpile tubular skeletal tower lighthouse is Sombrero Key Lighthouse (1858), Florida.

Screwpile: To increase the holding power of the pile, a screw-like flange was fastened to the bottom of the pile and wound like a screw into the substrate. There are two principal screwpile type lighthouses, 1) low spider-like foundations for rivers, bays, and sounds, and 2) tall offshore coastal towers. Perhaps as many as 100 spider-like screwpile lighthouses were built throughout the Carolina sounds, the Chesapeake Bay, Delaware Bay, along the Gulf of Mexico, and one even at Maumee Bay (1855) on Lake Erie in Ohio. Thomas Point Shoals Lighthouse (1875), Maryland, is the oldest extant, unmoved, spider-like screwpile lighthouse in the United States. The first of the tall skeletal screwpile coastal towers built in the United States was Carysfort Reef Lighthouse (1852), Florida, which still stands. A few offshore screwpile skeletal tower lighthouses built on coral reefs used foot plates or disks to help disperse the weight of the tower. Examples in the Florida Keys include Carysfort Reef Lighthouse (1852), Fowey Rocks Lighthouse (1878), and American Shoal Lighthouse (1880).

Crib: Wooden cribs, constructed onshore, towed to the site, and then filled with stone to sink them in place were a lighthouse foundation type

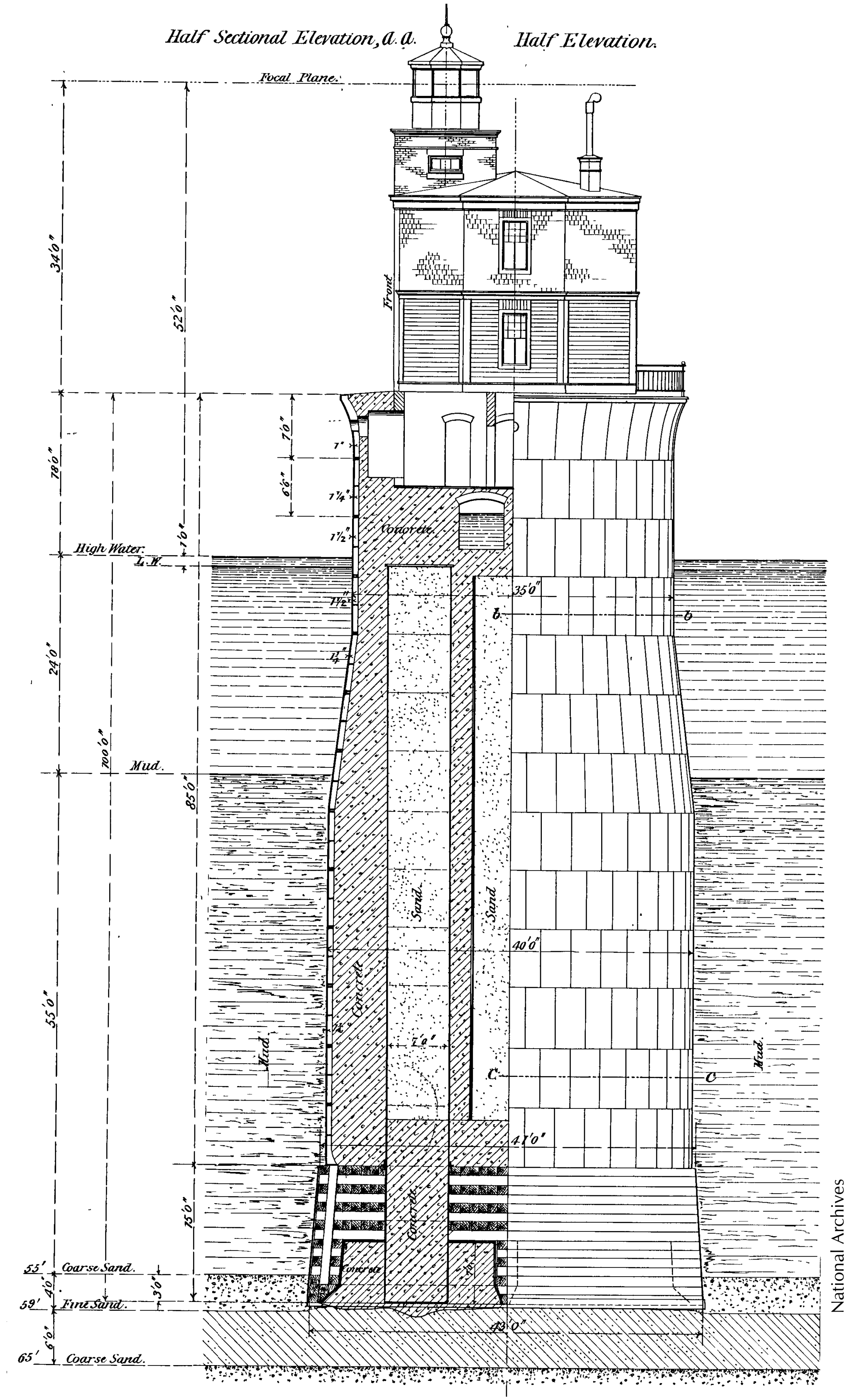


Figure 8. Construction drawing detailing the caisson foundation for Baltimore Lighthouse in Maryland's Chesapeake Bay.

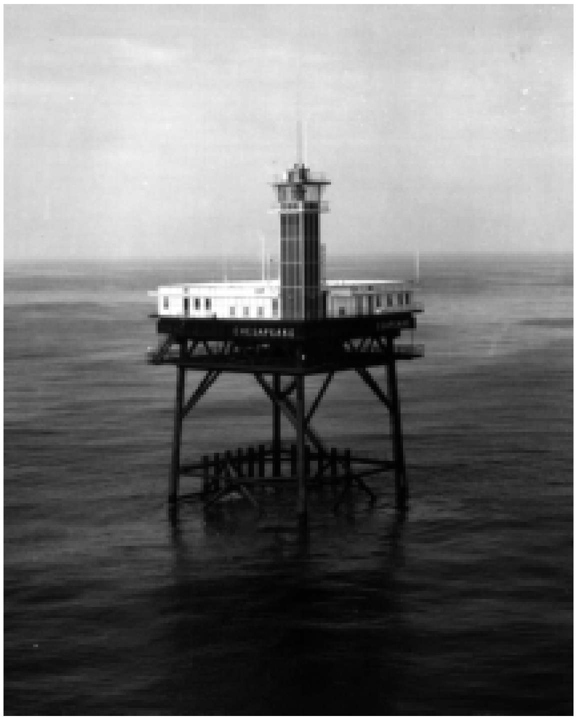


Figure 9. Chesapeake Light Station, Texas tower at entrance to Chesapeake Bay.

used extensively in the Great Lakes, usually to replace lightships. Once settled and leveled, the cribs were capped with concrete or some other masonry upon which the lighthouse structure was constructed. Perhaps the two most significant crib foundation lighthouses are the 93-foot Spectacle Reef Lighthouse (1874) on Lake Huron, Michigan, located 10½ miles from the closest land; and the 110-foot Stannard Rock Lighthouse (1882) on Lake Superior, Michigan, located 23 miles from the nearest land. Crib foundations were best suited for hardrock bottoms typically found in the Great Lakes.

Caisson: Caisson foundations were best suited for unconsolidated bottoms composed of sand or mud. The caisson lighthouse type used a large cast-iron cylinder, which was sunk on the bottom and filled with rock and concrete to form a foundation. The caisson foundation was sturdier and better able to withstand heavy stress than the pile foundation lighthouses, so it is not surprising that caisson lighthouses were built in areas where moving ice was a hazard. The Craighill Channel Lower Front Range Lighthouse (1873), Maryland, is an early surviving example. Where bottoms were harder, contained rocks, and/or needed greater depth of penetration into the substrate, the pneumatic process was used. The substrate within the caisson was removed and the caisson allowed to sink further into the bottom. Eleven pneumatic caisson lighthouses were built in the United States. The Sabine Bank Lighthouse (1905), Texas, is the most exposed, located 15 miles offshore in the Gulf of Mexico—the only successful caisson south of the Chesapeake Bay.[6]

Texas Tower Type: A relatively recent technological development in lighthouse construction was the Texas tower type which replaced exposed lightships offshore. These so-called Texas towers were adaptations modeled on the offshore oil drilling platforms first employed off the Texas coast. The first Texas tower lighthouse in the United States was the Buzzards Bay Light, located in Buzzards Bay, Massachusetts, and commissioned on November 1, 1961. It has been extinguished and may be dismantled. A total of six Texas tower lighthouses have been constructed.

[6] The caisson type lighthouse, though superior to the screwpile lighthouse type as far as stability is concerned—especially in northern locations where ice flow conditions exist, did not prove satisfactory for offshore ocean locations because of severe bottom scouring. In the late 1880s, a 54-foot-diameter pneumatic caisson foundation with a tall steel light tower was sunk off Diamond Shoals, thirteen miles off the shore from Cape Hatteras, North Carolina. But water currents scoured the site and tilted it out of level. The contractors gave up in disgust as did the Lighthouse Board after a few more unsuccessful attempts. (Wayne C. Wheeler, "Diamond Shoal Lighthouse: The Lighthouse That Never Was," *Keeper's Log* (1988) 4(3):24-29.)

Standards, Guidelines, and the Preservation Process

NMI photo

Figure 1. Sandbags are used to protect Cape Hatteras Lighthouse, Buxton, North Carolina, from further shoreline erosion.

Levels of Treatment According to the *Secretary of the Interior's Standards for the Treatment of Historic Properties* (1995)

The Secretary of the Interior is responsible for establishing professional standards and providing advice on the preservation and protection of all cultural resources listed in or determined eligible for listing in the National Register of Historic Places. The first standards developed to fulfill this responsibility were published in 1976—the *Secretary of the Interior's Standards for Historic Preservation Projects*. These consisted of seven sets of standards for the acquisition, protection, stabilization, preservation, rehabilitation, restoration, and reconstruction of historic buildings.

Since their publication in 1976, the *Secretary's Standards* have been used by State Historic Preservation Officers and the National Park Service to ensure that projects receiving federal money or tax benefits were reviewed in a consistent manner nationwide. The principles embodied in the *Standards* have also been adopted by hundreds of preservation commissions across the country in local design guidelines. The *Standards* also apply to all proposed development grant-in-aid projects assisted through the National Historic Preservation Fund.

In 1992 the *Standards* were revised so they could be applied to all historic resource types included in the National Register of Historic Places—buildings, structures, sites, objects, districts, and landscapes.[1] The revised standards were reduced to four sets by incorporating *protection* and *stabilization* into *preservation*, and by eliminating *acquisition*, which is no longer considered a treatment.

The Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings (1995) also replaced the *Guidelines* that were published in 1979 to accompany the earlier *Standards*, and address four distinct, but interrelated, approaches to the treatment of historic

[1]Retitled *The Secretary of the Interior's Standards for the Treatment of Historic Properties*, this new, modified version was codified as 36 CFR Part 68 in the July 12, 1995, *Federal Register* (Vol. 60, No. 133) with an "effective" date of August 11, 1995. The revision replaces the 1978 and 1983 versions of 36 CFR 68 entitled, "The Secretary of the Interior's Standards for Historic Preservation Projects."

properties: *preservation*, *rehabilitation*, *restoration*, and *reconstruction*.

Of the four, *preservation* standards require retention of the greatest amount of historic fabric and focus on the maintenance and repair of existing historic materials. It includes retention of a property's form, features, and details as they have evolved over time. *Protection* and *stabilization* have been consolidated under this treatment.

Rehabilitation standards acknowledge the need to alter or add to a historic property to meet continuing or changing uses while retaining the property's historic character. *Restoration* standards allow for the depiction of a property at a particular period of time in its history by preserving materials from the period of significance and removing evidence of other periods. *Reconstruction* standards establish a framework for recreating vanished or non-surviving portions of a property with new materials, primarily for interpretive purposes.

The Secretary of the Interior's Standards for the Treatment of Historic Properties may be used by anyone planning and undertaking work on historic properties, even if grant-in-aid funds are not being sought. They are regulatory only for projects receiving federal grant-in-aid funds; otherwise, they are intended only as general guidance for work on any historic building. Historic lighthouse owners, tenants, stewards and managers, preservation planners, historical architects and engineers, contractors, and project reviewers would all benefit from guidance contained in the *Standards* during the planning and implementation of project work.

It should be noted that another regulation, 36 CFR Part 67, focuses on "certified historic structures" as defined by the IRS Code of 1986. The "Standards for Rehabilitation" cited in 36 CFR 67 should always be used when property owners are seeking certification for Federal tax benefits.

In summary, the simplification and sharpened focus of this revised set of treatment standards is intended to assist users in making sound historic preservation decisions. Choosing an appropriate treatment for a historic property is critical. This choice always depends on a variety of factors, including the property's historical significance, physical condition, proposed use, and intended interpretation.

Preservation

Preservation is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of a historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses on the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

Preservation as a Treatment Philosophy: *Preservation* may be considered as a treatment when the property's distinctive materials, features, and spaces are essentially intact and thus convey the historic significance without extensive repair or replacement; when depiction at a particular period of time is not appropriate; and when a continuing or new use does not require additions or extensive alterations. Before undertaking work, a documentation plan for *preservation* should be developed.

The Secretary of the Interior's Standards for Preservation

1. A property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces, and spatial relationships. Where a treatment and use have not been identified, a property will be protected and, if necessary, stabilized until additional work may be undertaken.
2. The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.
3. Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate, and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.
4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.
5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.
6. The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color, and texture.
7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.
8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

(See Part IV. **Historic Lighthouse Preservation** in this Handbook for illustrations on how to apply preservation treatments to historic lighthouses in a way that meets the standards.)

General Guidelines for the Preservation Planning Process

Careful planning before treatment can help prevent irrevocable damage to a historic lighthouse. Professional techniques for identifying, documenting, and treating historic lighthouses are continually being refined. The preservation planning process for historic lighthouses should involve: historical research; identification of character-defining features; documentation of existing conditions; condition assessment and analysis; development of a strategy for ongoing maintenance, protection and/or stabilization; special requirements such as accessibility, health and safety considerations, and energy efficiency (sustainability); and preparation of a record of treatment which documents actual work accomplished as part of any preservation project.

Historical Research

Before undertaking project work, research should be conducted to determine if the lighthouse is historically significant (see "What Makes a Lighthouse Historic" under Part I). Research findings help to identify a light station's historic period(s) of ownership and occupancy, expansion and contraction, and bring greater understanding of the significant associations. Research findings also provide the foundation to make educated decisions for project treatment, and can guide management, maintenance, and interpretation. In addition, research findings may be useful in satisfying compliance reviews, e.g., Section 106 of the National Historic Preservation Act as amended. Most primary records on U.S. lighthouses are housed in the National Archives. For a description of these records, see Part VI., **Resources**.

Identification of Character-Defining Features

The *Secretary of the Interior's Standards for Preservation* embody two important goals: 1) the preservation of historic materials, and 2) the preservation of a building or structure's distinguishing character. Every historic lighthouse is unique, with its own identity and its own distinctive character. Character refers to all those visual aspects and physical features that comprise the appearance of every historic structure. Character-defining features include elements such as the overall shape of the lighthouse structure/building, its materials, craftsmanship, decorative details, interior spaces and features, as well as various aspects of its site and environment.

If the various materials, features, and spaces that give the lighthouse its visual character are not recognized and preserved, then essential aspects of its character may be damaged in the process of change. The character of a historic lighthouse can be changed or damaged in many ways: for example, by inappropriate repointing of the brickwork, or the application of a coating over the brick surfaces, by removal of a distinctive entry way, by changes to the window sash or lantern glazing, by removal of the classical lens, by changes to the exterior such as changing the daymark, or by the introduction of new elements such as modern radar or electrical equipment, or the addition of chain link fences to replace historic fencing types, etc.

A three-step process has been developed by the National Park Service that can be used by anyone to identify those materials, features, and spaces that contribute to the visual character of a historic lighthouse and its environs. Step one, examine the structure from afar to understand its overall setting and architectural context; step two, move up very close to appreciate its materials and the craftsmanship and surface finishes evident in these materials; step three, go into and through the structure to perceive those spaces, rooms, and details that comprise its interior visual character.

For examples of character-defining features that are typically found associated with historic lighthouses, see the section on identifying character-defining features in the Introduction to Part IV., **Historic Lighthouse Preservation**.

Documentation of Existing Conditions

The goal of documentation is to provide a record of the lighthouse as it exists at the present time, thus providing a baseline from which to operate. All character-defining features that contribute to the lighthouse's historic character should be recorded. The level of documentation needed depends on the nature and significance of the lighthouse. A building should be documented before any inventory, stabilization, or investigative work in order to record crucial material evidence.

A simple, comprehensive method is to take 35mm photographs of all sides of the structure (interior and exterior), as well as general views, and typical and unusual details. The systematic numbering of levels, rooms, windows, and doors on the floor plan will help organize this task and also be useful for labelling the photographs. It is also useful to establish the relative size of the features by including a scale-setting device in the photo field. A common scaling device is the "scale bar," a four- to six-foot-long rectangular bar, approximately one foot in width, with black and white alternating one-foot increments. Color-print and black-and-white film are recommended over slide film for the archival stability. Video coverage with annotated sound may supplement still photographs. Additional methods of documentation include written descriptions, sketches, inspections, and measured drawings.

Significant structures, such as National Historic Landmarks or individually listed National Register properties, could benefit from professional large format photographic documentation and accurate measured drawings. Professionals frequently refer to *The Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation; the HABS/ HAER Standards (Historic American Buildings Survey/ Historic American Engineering Record)*. Remember that the documents created during investigation may play an unforeseen role in future treatment and interpretation. Documentation is particularly valuable when a feature will be removed, altered, or lost.

The documentation process can be quite extensive if the budget allows; if funds are limited, there are rudimentary alternatives. Throughout the country there are architectural, engineering, and preservation firms that specialize in historic documentation and research. For a listing of firms in your vicinity contact your State Historic Preservation Officer. The work performed by these firms can cover a wide range of products. At minimum a site visit report can be made after a one-day site visit that produces a series of documentation photographs and a written description of the historic and character-defining features of the structure. The ultimate documentation of a historic lighthouse would be a historic structure report that may involve a complete history of the structure, development chronology of the structure, paint analysis, inspection of interior wall cavities with a boroscope, extensive materials testing, large format photography, and collection of historic photographs.

If the budget does not allow for this type of extensive documentation, certain minimum documentation should be performed before any work is undertaken. Black-and-white photographs should be taken of all elevations of the lighthouse as well as character-defining details such as deck brackets, door and window surrounds; lantern elements and equipment; interior features such as wall surfaces and staircases; and any architectural millwork such as chair rail, baseboard, etc. These photographs will document the pre-existing conditions of the lighthouse and serve as a record for future work. Each photograph should be accompanied by a written description of the image. The photographs and descriptions should be archived together with all known information about the lighthouse, such as maintenance records, any historical research already performed, etc.

SIDEBAR: Documenting Historic Lighthouses by the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER)

In many cases, the first step in the preservation of a lighthouse, or any historic property, is documentation. The existing site should be recorded with drawings, photographs and historical and descriptive reports to define the characteristics and significance of that site. The HABS/HAER program of the National Park Service was created in 1933 to develop this type of documentation, establishing a standardized collection of the American-built environment, held for perpetuity within the Prints and Photographs Division of the Library of Congress. All materials are produced to

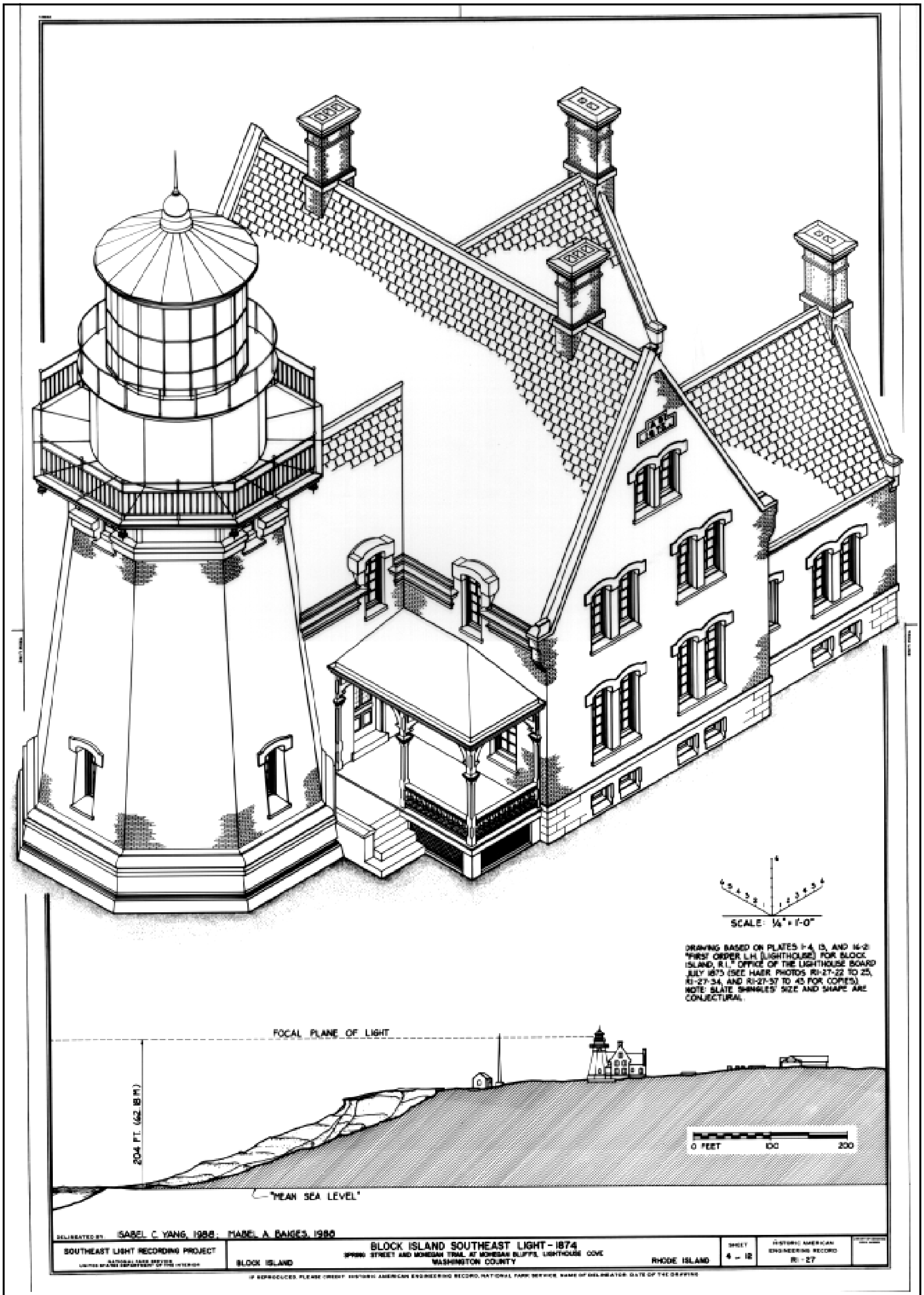


Figure 2. Isometric drawing from HAER documentation of Block Island Southeast Lighthouse, Block Island, Rhode Island (HAER RI-27).

archival standards and specific formats that assure a consistent product throughout the collection. This collection is available to the public and reproductions of the records can be obtained.

HABS/HAER documentation is usually in the form of measured drawings, photographs, and written data. The kind and amount of documentation should be appropriate to the nature and significance of the lighthouse being documented. Level I documentation, which is generally required for nationally significant properties, includes a full set of measured drawings depicting existing or historic conditions, photographs with large-format negatives of exterior and interior views, large format negatives of photocopies of select existing drawings or historic views where available, and a written history and description. Level II documentation differs from Level I by substituting copies of existing drawings, either original or alteration drawings, for recently executed measured drawings. Level III documentation substitutes a sketch plan with an architectural data form explaining what is not readily visible in the photographs and Level IV documentation consists solely of completed HABS/HAER inventory cards.

The HABS and HAER programs vary slightly in the process by which a site is recorded. HABS generally focuses on architectural features and prepares documentation that reflects the "as is" existing condition of a site with historical background information in a written format. Little notation is made on the drawings. HAER generally focuses on engineering principles and industrial structures, and prepares a record that interprets the site for its significant engineering or function. Often, the interpretive drawings utilize existing documents as a basis for the measurements rather than measuring the structure in the field; the objective is to interpret a concept, not necessarily an existing condition, so that the structure can be rebuilt exactly in all its historic details.

The documentary record can explain the form or function of lighthouses using a variety of graphic techniques. The basic drawing includes measured elevations, plans, and sections. More intricate interpretive drawings use axonometric techniques to explain the three-dimensional forms and arrangement of parts. These include planometrics (a rotated plan with vertical elements projected from it), or isometic projections which utilize a 30-degree angle in its base axis (see Figure 2). Axonometrics are also used to develop "exploded" or "peel-away" views that illustrate how pieces fit together. Photographs or conceptual information are often translated into illustrations or sketches that further explain a process or character of the structure.

Large-format black-and-white photography is used to capture the actual physical attributes of the structure and express its context in the landscape and relationship to other structures around it. Photography also provides greater textural details of the material's weathered condition. Written documentation provides the basic data necessary for understanding the site's development and evolution throughout its working life. Specific descriptive information is recorded, and historical research explains the context, functions, alterations, and theories related to its operation.

Condition Assessment and Analysis

A condition assessment can provide the owner with an accurate overview of the current condition of the property. Architectural investigation is the critical first step in planning an appropriate treatment—understanding how a building has changed over time and assessing levels of deterioration. If the lighthouse is deteriorated or if there are significant architectural elements that will need special protection, undertaking a condition assessment is highly recommended, but it need not be exhaustive. Both the purpose and scope of the assessment should be determined before formulating a particular approach. Any maintenance or repair problems should be identified and prioritized.

A modified condition assessment, prepared by an architect or preservation specialist or in some cases a structural engineer, may help set priorities for repairs necessary to stabilize the property for both the short and long term. It will evaluate the age, condition, and quantities of the following major elements: foundations; structural systems; exterior materials and surfaces; roofs and gutters; exterior porches and steps; interior finishes; staircases; plumbing, electrical, mechanical systems; special features such as chimneys; and site drainage. Throughout the country there are architectural, engineering, and preservation firms that specialize in assessing the condition of historic structures. For a listing of firms in your vicinity that specialize in condition assessments, contact your State Historic Preservation Officer.

Condition assessment surveys can, however, be carried out by a maintenance team familiar with the unique qualities of historic lighthouses and their maintenance requirements. Visual surveys will quickly point out any obvious deficiencies to a well-trained eye. Observations can be documented on any standard maintenance survey form or on individually prepared survey forms that are tailored to a specific site.

Strategy for Maintenance

- Identify character defining features
- Prepare feature checklist for condition assessment
- Determine condition: good, fair, poor
- Prioritize maintenance concerns: critical, serious, minor
- Develop a maintenance and monitoring plan
- If appropriate, determine quantities of existing materials for future cost estimates

Maintenance of any structure begins with scheduled inspections and cyclic and routine maintenance. Scheduled inspections are the most basic form of maintenance and are critical in the long-term preservation of a lighthouse structures. The inspection process is a method for identification of maintenance issues and should be carried out on a regular basis (quarterly, semi-annual, annual, every second-, third-, fourth-, or fifth-year cycle). Lighthouse structures are typically located in harsh coastal environments and should be inspected at least annually; if inspection personnel have appropriate preservation skills, it would be cost effective to undertake basic emergency repairs in the field such as securing open doors and windows and performing temporary repairs.

For lighthouse structures which have recently been preserved, comprehensive inspections should be scheduled once every three to five years. Annual visual inspections, and inspections after major weather events would also be recommended. This procedure identifies 'problems' so that treatment can be scheduled during the next maintenance cycle. If the recommended preservation treatments are carried out, the annual maintenance will be routine in nature. Cyclical maintenance planning would allow for three-to-five and ten-year cycles for maintenance activities such as repainting, reglazing, recaulking, etc.

Lighthouses are unique structures in that they were originally constructed to endure severe weather. Because they have survived 80 to 100 years, the uninformed public may assume these structures require little or no upkeep. But lighthouses were

SIDEBAR: Quantities Tracking, Tallying, and Cost Estimating

Cost estimates are frequently requested products of condition assessment projects and are very useful in planning the preservation strategy. Lighthouses are also one of the most difficult building types to estimate. Development of cost estimates for preservation projects is often based on previously completed work. Prices are compiled for various tasks and a database is created. This method is used most often to create cost estimates for proposed or recommended projects, including preservation.

In order to create an estimate, quantities tracking is an essential step. Time should be allocated during regularly scheduled inspections to measure and tally the quantities of materials which make up the lighthouse. Geometric calculations will come into play in the determination of various components and features of any lighthouse given their often circular or conical shape. If any documentary drawings are available for the lighthouse, the recorded dimensions can be used to calculate materials quantities.

Once quantities have been figured, it is possible to proceed with a cost estimate. Cost estimates may be produced in a variety of formats depending on the developmental stage of the project and the needs of the project managers. The following is a description of some of the most common types of cost estimates and their uses.

Many government agencies develop "in-house" estimating guidelines based on previous project work. Conceptual cost estimates, or class "C" estimates are often based on per square foot costs derived from similar construction or identifiable unit costs of similar construction items. These estimates may be prepared without a fully defined scope of work.

There are many considerations in preparing a conceptual estimate, such as job location, materials suppliers, labor availability and wage rates, seasons of construction, difficulty of accessing the structure, geographic areas, and difficulty of terrain.

When preparing an estimate the following information is critical: square footage of the structure and other important dimensional data (how tall, etc.), anticipated site development including existing and proposed utilities, anticipated mechanical and electrical needs, anticipated structural needs, and anticipated construction constraints or unusual site conditions. Given that historic lighthouses are a unique type of structure there are many other factors to be considered. These must be determined on a case-by-case basis.

Other more refined estimates are based on an approved preliminary design. This type of estimate or class "B" is derived from partial lump sum and unit costs. Important information to consider includes: site planning (existing and proposed utilities, grading, planting, etc.); building design (plans, elevations, and sections, plus details of the work); schematic mechanical and electrical systems design (may be in the form of written analysis based on available information); outline specifications including cut sheets of proposed materials, equipment, fixtures or specialty items which may significantly influence the estimate); and initial quantity take-offs for utilities, site, and building systems (civil, landscape architectural and preservation architectural).

The best type of estimate is based on a complete quantity take-off derived from completed construction documents and specifications. This is characterized as a class "A" estimate. This type of estimate is completed when a project is ready to be competitively bid. Support information should include: final construction drawings and specifications, estimate based on complete quantity take-offs, and a final bid schedule prepared by the architect.

References:

There are many types of estimating guidelines available for general use, this is a list of those most commonly found. Consult your local library or bookstore for others. Keep in mind that lighthouses are unique structures and a certain amount of interpolation may be required.

Walker's Building Estimator's Reference Book (annual updates): *A Reference Book Setting Forth Detailed Procedures and Cost Guidelines for Those Engaged in Estimating Building Trades*, Frank A. Walker Company, Lisle, Illinois

National Construction Estimator (annual updates), Craftsman Book Company, Carlsbad, California

Means Building Construction Cost Data (annual updates), R.S. Means Company, Kingston, Massachusetts

Successful Estimating Methods: From Concept to Bid (First Edition), by John D. Bledsoe, Ph.D., P.E., R.S. Means Company, Kingston, Massachusetts, 1996

also designed for a live-in keeper. A trained professional was on hand everyday to monitor the condition of the structure and perform the daily maintenance and upkeep required at a functioning light. If there was a catastrophic occurrence, the keeper was there to take immediate action and follow through with residual repairs. The keeper was the eyes and ears of the lighthouse. In today's unmanned stations this critical link has been lost. In a sense, the role of the keeper is replicated by the scheduled inspection and cyclic maintenance process.

While every effort may have been made to stabilize the property and to slow the deterioration of materials, natural disasters, storms, undetected leaks, and unwanted intrusion can still occur. A regular schedule for monitoring and maintenance should be established to track these events. The regularly scheduled inspection is also the tool for monitoring recent work and for creating a record of the changes to the structure. It is the primary means for monitoring during the post construction phases of a project. (For more information see the inspection charts provided in Part IV. **Historic Lighthouse Preservation**.)

Special Requirements

Work that must be done to meet accessibility, health and safety, or energy efficiency requirements is usually not part of the overall process of protecting historic lighthouses; rather, this work is assessed for its potential impact on the historic lighthouse.

- ***Accessibility requirements***: Modifications to historic lighthouses and associated historic structures are often necessary so that they will be in compliance with current accessibility code requirements. Accessibility to certain historic structures is required by three specific federal laws: the Architectural Barriers Act of 1968, Section 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act (ADA) of 1990. Federal rules, regulations, and standards have been developed which provide guidance on how to accomplish access to historic areas for people with disabilities. Work must be carefully planned and undertaken so that it does not result in the loss of character-defining spaces, features, and finishes. This can be especially challenging given the vertical and confined nature of most lighthouses. The goal is to provide the highest level of access with the lowest level of impact. Often a programmatic solution will satisfy the intent of the laws and provide the highest level of access. (See section on ADA under Safety Management Issues under Part V., **Related Activities** for more information.)

- ***Health and safety considerations***: In undertaking work on historic lighthouses, consider the impact that meeting current health and safety codes (for example, public health, life safety, fire safety, electrical, seismic, structural, and building codes) will have on character-defining spaces, features, and finishes. Special coordination with the responsible code officials at the state, county, or municipal level may be required. Securing required permits and licenses is best accomplished early in work project planning. It is often necessary to look beyond the 'letter' of code requirements to their underlying purpose; most modern codes allow for alternative approaches and reasonable variance to achieve compliance.

  Some historic building materials (insulation, lead paint, mercury bearings, etc.) contain toxic substances that are potentially hazardous to building occupants. Following careful investigation and analysis, some form of abatement may be required. Hazardous materials, especially those historic in nature, may also be managed in place if maintained in good condition. All workers involved in the encapsulation, repair, or removal of known toxic substances should be adequately trained and should wear proper personal protective gear. Finally, preventative and routine maintenance for historic lighthouse structures known to contain such materials should include proper warnings and precautions. (See Safety Management Issues under Part V., **Related Activities**, for more information.)

- ***Energy efficiency (sustainability)***: Some features of a historic lighthouse, associated structure, or site such as cupolas, shutters, transoms, windows, ventilation systems, porches, or plantings can play an energy-conserving role. Therefore, before retrofitting historic structures to make them more energy efficient, the first step should always be to identify and evaluate existing historic features to assess their inherent energy-conserving potential. If it is determined that retrofitting measures are appropriate, then such work needs to be carried out with particular care to ensure that the lighthouse's historic character is retained.

Preparation of a Record of Treatment

The *Record of Treatment* is a compilation of information documenting actual treatment. The report usually consists of two parts.

Part 1, the *Completion Data,* summarizes in narrative form, the intent of the work, the way in which the work was approached and accomplished, conditions encountered, materials used, the time required to do the work, and the cost of the work. It also describes the history of the structure based on physical evidence discovered during construction.

Part 2, the *Project History* contains technical data such as copies of field reports and other pertinent correspondence, material data sheets, field notes, details, site maps, accounting data spread sheets (list of project expenses), and narrative contract summaries. More detailed reports will include lists of materials (type and quantity) and where they were purchased (material/vendors charts).

In addition to written reports, graphic documentation is particularly appropriate for any work that changes the form or substance of a historic lighthouse. Drawings and annotated photographs (before, during, and after) will be provided in appendices or integrated into the text of the report.

The *Record of Treatment* is produced to enhance the management and research database for historic lighthouse structures. This documentation is essential in evaluating maintenance procedures, forecasting cyclic maintenance, and interpreting the integrity of each structure.

Historic Lighthouse Preservation:

Introduction

Figure 1. Brick replacement in 1996 restoration at Cape Florida Lighthouse on Key Biscayne, Florida.

Preserving Historic Lighthouses

The expressed goal for preserving historic lighthouses in Part III., **Standards, Guidelines, and the Preservation Process** is retention of the building's existing form, materials, features, and detailing. This may be as simple as basic maintenance of existing materials and features or may involve preparing a historic structures report, undertaking laboratory testing such as paint and mortar analysis, or conducting condition assessments. Protection, maintenance, and repair are emphasized while replacement is minimized. In *preservation*, the options for replacement are less extensive than in the treatment, *rehabilitation*. This is because the assumption at the outset is that building materials and character-defining features are essentially intact.

Preservation encompasses all of the maintenance issues confronting historic lighthouses; there is no one set of procedures that can be applied to every repair or maintenance scenario. The following basic concepts should, however, be applied to all preservation activities including repair and maintenance of historic character-defining features. Preservation must be considered as an option for the interim treatment of a historic lighthouse as well as the possible ultimate treatment. This decision depends on all those issues previously addressed in the "General Guidelines for the Preservation Planning Process" in Part III and on the individual qualities, integrity, and condition of the historic lighthouse in question.

Identify, Retain, and Preserve Historic Materials and Character-Defining Features

The guidance for the preservation treatment begins with recommendations to identify the form and detailing of those architectural materials and features that are important in defining the lighthouse's historic character and which must be retained in order to preserve that character. Therefore, guidance on identifying, retaining, and preserving character-defining features is always given first.

Identify the character-defining features of the historic lighthouse. Character-defining features are found on both the interior and exterior of the structure. These features include but are not limited to:

- the overall massing and shape of the lighthouse;
- the detailing of exterior materials used in the construction of the lighthouse, e.g., wood, brick, stone, concrete, cast iron, etc.;
- exterior features, such as roofs, lanterns, porches, and daymarks;
- configuration and type of windows, e.g., wood double-hung multiple-lite, wood casement, metal casement, etc.;
- door configuration, e.g., board and batten, raised panel, plank, etc.;
- door and window opening treatments, e.g., sidelights, transoms, fanlights, ornamental trim, detailed lintels, etc.;
- the interior materials, such as plaster and paint; the interior features, such as stairways and moldings, room configurations, and spatial relationships, as well as structural and mechanical systems;
- support buildings such as keeper's dwelling, oil house, fog signal building, barn, boathouse, privy, etc.
- site features such as roads and walkways, fences, flag poles, planters, water collection systems, docks and wharves, beachheads, seawalls, boat launch tracks, gardens, etc.; and
- lantern equipment including lenses, lens supports, etc.[1]

Once the character-defining features are identified, an assessment should be made of those features and their physical condition at the time of the survey. The assessment should include all information known about the features such as material type, size, last time the feature was serviced, e.g., painted, repaired, replaced, etc., and the approximate age of the feature, e.g., does the feature appear to be original? or does the feature appear to be a replacement? This assessment should be kept in the maintenance file of the lighthouse in order to better plan future repair and maintenance tasks.

Retain the character-defining features and the qualities of the historic lighthouse to the greatest extent possible during any repair or maintenance activity. Once the character-defining features are identified, future repair and maintenance tasks should be planned to maintain these features, prevent them from deteriorating, and thereby prevent their loss. If a feature must be removed to address a repair issue, e.g., removal of cornice brackets during a roofing or deck repair, the features should be carefully removed and labeled in such a manner that the reinstallation of the features can be easily and correctly accomplished.

Preserve the character-defining features and qualities of the historic lighthouse through in-kind repairs and routine maintenance activities. During any repair or maintenance activity, the ultimate goal must be to preserve

[1]U.S. Coast Guard policy states that "Classical lenses are of special historical interest. Classical lenses rotating on mercury floats should be modified, if possible, or replaced because of the special maintenance and safety requirements of this system. Classical lenses using other rotating systems, which remain serviceable, should be retained. Any modifications or replacement of a classical lens must be coordinated with the appropriate historic preservation interests. . . . Non-rotating classical lenses should be retained if serviceable. Modification or replacement of a classical lens must be coordinated with the appropriate historic preservation interests." (COMDTINST M16500.8A)

the lighthouse in a manner that utilizes the most sensitive means available.

For more information on this process see the National Park Service *Preservation Briefs 17: Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character.*

Stabilize and Protect Deteriorated Historic Materials and Features as a Preliminary Measure

Deteriorated portions of a historic lighthouse may need preliminary stabilization and protection measures to safeguard those features until additional work can be undertaken. Stabilization involves re-establishing the stability of an unsafe, damaged, or deteriorating structure while maintaining its existing character.

Stabilizing may include emergency short- or long-term measures; long-term structural reinforcement, weatherization, or ventilation; or correcting unsafe conditions. Temporary stabilization should always be carried out in such a manner that it detracts as little as possible from the historic lighthouse's appearance. Although it may not be necessary in every preservation project, stabilization is nonetheless an integral part of the preservation treatment; it is equally applicable, if circumstances warrant, for the other treatments.

Maintain Historic Materials and Features

After identifying those materials and features that are important and must be retained in the process of preservation work, their protection and maintenance is addressed. Protection generally involves the least degree of intervention and is preparatory to other work. For example, protection includes the maintenance of historic materials through treatments such as rust removal, caulking, limited paint removal, and re-application of protective coatings; the cyclic cleaning of roof gutters and internal ventilation systems; or installation of fencing, alarm systems, and other temporary protective measures. Although a historic lighthouse will usually require more extensive work, an overall evaluation of its physical condition should always begin at this level.

SIDEBAR: Protection/Stabilization ("Mothballing") of Historic Lighthouses

When all means of finding a productive use for a historic lighthouse have been exhausted or when funds are not currently available to restore a deteriorating structure into a useable condition, it may be necessary to temporarily close up or deactivate the building to protect it from the weather as well as to secure it from vandalism. This process, known as "mothballing," can be a necessary and effective means of protecting the lighthouse while planning the lighthouse's future or raising money for a preservation, rehabilitation, or restoration project. If a vacant lighthouse has been declared unsafe by building officials, a protection/stabilization program may be the only way to protect it from demolition.

Protection/stabilization involves controlling the long-term deterioration of the lighthouse while it is unoccupied as well as finding methods to protect it from sudden loss by fire or vandalism. This requires securing the lighthouse from unwanted entry, providing adequate ventilation to the interior, and shutting down or modifying existing utilities. Once the lighthouse is deactivated or secured, the long-term success will depend on periodic maintenance and surveillance monitoring.

Protection/stabilization is a treatment that can be tailored to suit a lighthouse's immediate and/or interim needs. Protection/stabilization can be used to secure a lighthouse after a catastrophic event until more permanent repairs can be undertaken. While providing some level of protection against the loss of significant historic materials and features, protection/stabilization is frequently used to buy time for the planning or funding needed to undertake a more permanent treatment such as restoration. As an interim treatment, mothballing activities should always be designed so they are reversible and contribute to the structure's ultimate treatment whether that be preservation or restoration.

When carried out in a manner sensitive to the historic nature of the lighthouse, protection/stabilization encompasses preliminary measures to protect and secure the property for an extended period of time. This includes correcting deficiencies to slow the rate of deterioration of the structure. These activities should not be done without careful planning to ensure that needed physical repairs are made before securing the lighthouse. The steps discussed in this text can protect lighthouses for periods of up to ten years; long-term success will also depend on continued, although somewhat limited, monitoring and maintenance. For all but the simplest projects, hiring a team of preservation specialists is recommended to assess the specific needs of the structure and to develop an effective mothballing program.

A vacant historic lighthouse cannot survive indefinitely in a boarded-up condition; even marginal interim uses where there is regular activity are generally preferable to mothballing. If a long-term treatment is the only remaining option, it must be done properly. This will require stabilization of the exterior, properly designed security protection, generally some form of interior ventilation—either through mechanical or natural air exchange systems—and continued maintenance and monitoring.

Comprehensive protection and stabilization programs are generally expensive and may cost 10% or more of a modest rehabilitation budget. The money spent on well-planned protective measures, however, will seem small when amortized over the life of the resource. Regardless of the location and condition of the property or the funding available, the following steps are involved in properly mothballing a lighthouse:

Document the architectural and historical significance of the lighthouse. Documentation of the historical significance and physical condition of the property will provide information necessary for setting priorities and allocating funds. The project team should be cautious when first entering the lighthouse structure if it has been vacant or is deteriorated. It may be advisable to temporarily brace areas appearing to be structurally unsound until the condition of the structure can be fully assessed. If pigeon or bat droppings, friable asbestos, or other health hazards are present, precautions must be taken to wear the appropriate safety equipment when first inspecting the lighthouse. Consideration should be given to hiring a firm specializing in hazardous waste removal if these highly toxic elements are found in the lighthouse.

Prepare a condition assessment. A condition assessment will provide the owner with an accurate overview of the current condition of the property. If the lighthouse is deteriorated or if significant interior architectural elements will need special protection during the mothballing years, a condition assessment is highly recommended, but it need not be exhaustive.

A modified condition assessment, prepared by an architect or preservation specialist, and in some case a structural engineer, will help set priorities for repairs necessary to stabilize the property for both the short- and long-term. It will evaluate the age and condition of the following major elements: foundations; structural systems; exterior materials; roofs and gutters; exterior porches and steps; interior finishes; staircases; plumbing, electrical, mechanical, and lightning protection systems; features such as dormers and chimneys; and site drainage.

Structurally stabilize the lighthouse, based on a condition assessment. Stabilization involves correcting deficiencies to slow the deterioration of the lighthouse while it is vacant. Weakened structural members that might fail altogether in the coming years must be braced or reinforced; insects and other pests removed and discouraged from returning; and the lighthouse protected from moisture damage both by weatherizing the exterior envelope and by handling water runoff on the site. Even if a modified use or caretaker services can eventually be found for the lighthouse, the following steps should be addressed.

- ***Structurally stabilize the lighthouse.*** In rare cases bracing may have been required to make the lighthouse temporarily safe for inspection; the condition assessment may reveal areas of hidden structural damage. Roofs, foundations, walls, interior framing, porches, chimneys, and dormers all have structural components that may need added reinforcement. Structural stabilization by a qualified contractor should be done under the direction of a structural engineer or a preservation specialist to ensure that the added weight of the reinforcement can be sustained by the lighthouse and that the new members do not harm historic finishes. Any major vertical post added during the stabilization should be properly supported and, if necessary, taken to the ground and underpinned.
- ***Exterminate or control pests, including termites and rodents.*** Pests can be numerous and include squirrels, raccoons, bats, mice, rats, snakes, termites, moths, beetles, ants, bees and wasps, pigeons, owls, and other birds. Termites, beetles, and carpenter ants destroy wood. Mice, too, gnaw wood as well as plaster, insulation, and electrical wires. Pigeon, bat, and rodent droppings not only damage wood finishes but create a serious and sometimes deadly health hazard.
- ***Protect the exterior envelope from moisture penetration.*** It is important to protect the exterior envelope from moisture penetration before securing the lighthouse. Leaks from deteriorated or damaged roofing, decks (that cover interior spaces) from around windows and doors, or through deteriorated materials, as well as ground moisture from improper site runoff or rising damp at foundations can cause long-term damage to interior finishes and structural systems.

  Ground water, at the ground surface and below the surface, does much more damage to unconditioned buildings than to conditioned and occupied buildings. It is critical that any roofs, gutters, or downspouts be in good working order and cleaned seasonally. The soil surface around the lighthouse should slope away from the building, without any opportunity for puddles to form at the base. The soil that is in contact with the foundation should never be allowed to be saturated with water, otherwise there may be damage from water erosion, mold growth, ice lensing, frost heave, or seepage. Any serious deficiencies on the exterior, identified in the condition assessment, should be addressed.
- ***Secure the lighthouse and its component features to reduce vandalism or break-ins and natural disasters.*** Securing the lighthouse from sudden loss is a critical aspect of protection and stabilization. Because historic lighthouses are irreplaceable, it is vital that vulnerable entry points are sealed. This includes doors and lower level windows.

- ***Providing adequate ventilation to the interior.*** Once the exterior has been made weathertight and secure, it is essential to provide adequate air exchange throughout the lighthouse. Without adequate air exchange, humidity may rise to damaging levels, and mold, rot, and insect infestation are likely to thrive. The needs of each historic resource must be individually evaluated because there are so many variables that affect the performance of each interior space once the lighthouse has been secured. In some circumstances, providing heat during the winter, even at a minimal 45° Fahrenheit (7° C), and utilizing forced-fan ventilation in summer will be recommended and will require retaining electrical service. For masonry lighthouses it is often helpful to keep the interior temperature above the spring dew point to avoid damaging condensation. In most lighthouses the need for summer ventilation outweighs the winter requirements.
- ***Secure or modify utilities and mechanical systems.*** This would include, depending on the circumstances, decommissioning the electrical system although it may be necessary for security or operating the optic. A more appropriate treatment would be to have the 'live' systems inspected by qualified electricians, etc., to insure that everything is 'up to code' and that deteriorating panel boxes are not about to short out, etc. Other historic systems should also be considered, if applicable. New systems which may be considered practical for *temporary* installation as part of the mothballing treatment would be: passive or forced ventilation, heating in the lantern area, temperature and/or humidity monitors, a security/motion detector system, or a system for fire protection. These are all sensitive systems and would require some degree of human monitoring and maintenance, providing additional security.
- ***Develop and implement a maintenance and monitoring plan for protection.*** With the installation of monitoring systems and devices it becomes necessary for human attendants to pay regular visits. Historic lighthouses were once occupied by a live-in attendant who lavished it with daily care. In this age of remote and automated operation, historic lighthouses are often expected to go unattended for months at a time. Some level of scheduled inspection, monitoring, and maintenance is required for the designed life of the protection and stabilization treatment. The cycle of these visits should be tied to the quality and security of the mothballed structure. If designed to last three to five years, an increase in the frequency of site visits would be expected in the third year; by the fourth year, a new treatment would be required or the previous one renewed. It is not unusual for a structure originally intended to be mothballed for five years to have this time period stretch to eight or even ten years. If this situation presents itself, be aware that certain aspects of the original five-year program will have to be restored or renewed at that time.

Providing temporary protection and stabilization for vacant historic lighthouses and ancillary structures (keeper quarters, oil houses, boat houses, sheds, outbuildings, privies, etc.) can arrest deterioration and buy the owner valuable time to raise money for preservation or to find a compatible use for the property. While these issues may seem simple, the variables and intricacies of possible solutions make the decision-making process very important. Each building must be individually evaluated before any work takes place. In addition, a variety of professional services as well as volunteer assistance are needed for careful planning and repair, sensitively designed protection measures, follow-up security surveillance, and cyclical maintenance. In planning for the future of the structure, complete and systematic records should be kept and generous funds allocated for mothballing to ensure that the historic property will be in stable condition for its eventual preservation, rehabilitation, or restoration.

(See NPS *Preservation Briefs 31: Mothballing Historic Buildings* for more information.)

Repair (Stabilize, Consolidate, and Conserve) Historic Materials and Features

When the physical condition of the character-defining materials and features requires additional work, repair by stabilizing, consolidating, and conserving is recommended. Repair generally focuses upon the ongoing maintenance of historic materials and features rather than extensive replacement and new construction.

Preservation strives to retain existing materials and features while employing as little new material as possible. Consequently, guidance for repairing a historic material such as masonry again begins with the least degree of intervention possible, such as strengthening fragile materials through consolidation, when appropriate, and repointing with mortar of appropriate strength. Repairing masonry as well as wood and architectural metal features may also include patching, splicing, or otherwise reinforcing them using recognized preservation methods. Similarly, within the preservation treatment, portions of a historic structural system could be reinforced using contemporary materials such as steel rods or wood bracing. All work should be physically and visually compatible, identifiable upon close inspection, and documented for future research.

Limited Replacement In Kind of Extensively Deteriorated Portions of Historic Features

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the limited replacement in kind of extensively deteriorated or missing parts of features when there are surviving prototypes (for example, gallery brackets, steps, window casings, hardware, railings, or portions of roofs). The replacement material needs to match the old both physically and visually, i.e., oak with oak, cast iron with cast iron, etc.

Thus, with the exception of hidden structural reinforcements and new mechanical system components, the wholesale use of substitute materials is generally not appropriate in the preservation treatment. Although using the same kind of material is always the preferred option, substitute materials may be acceptable in certain instances, i.e., repairing a damaged piece of historic lantern glazing, if the form and design, as well as the material itself, convey the visual appearance of the remaining parts of the feature and finish. Again, it is important that all new material be identified and properly researched for future needs.

If prominent features such as interior staircase, exterior cornice, or roof ventilator are missing, then a *rehabilitation* or *restoration* treatment may be more appropriate.

These treatments are critical components of the process and should not be overlooked. Treatment measures should not result in permanent damage, and so each should be weighed in terms of its reversibility and its overall benefit. New exterior additions or reconstruction are not within the scope of any of these treatments.

Preserving Materials and Features in Historic Lighthouses

The following sections recommend treatments for the preservation of historic lighthouses based on the *Secretary of the Interior's Standards for the Treatment of Historic Properties*.

The information presented is designed to be used as a general preservation treatment guide for managers of historic lighthouses. The materials and features are divided into eight sections: masonry, iron, wood, and concrete construction; windows; doors; lanterns; interiors; and grounds. Each section deals with two levels of preservation: protection/ stabilization (mothballing) and repair.

The raw data used for this text were collected during a lighthouse condition assessment project performed by the NPS Historic Preservation Training Center (formerly the Williamsport Preservation Training Center) in cooperation with the U.S. Lighthouse Society and the NPS National Maritime Initiative. During this project, site visits were made to 21 DoD- and USCG-owned light stations. These structures were located in various parts of the country; states visited included California, Delaware, Florida, Maine, Maryland, Michigan, New Jersey, New York, and North Carolina, Oregon, and Virginia. The sites were chosen because they represented the full range of construction types.

In addition to the raw data, resources for the treatment sections of this handbook include the *Secretary of the Interior's Standards for the Treatment of Historic Properties,* technical information from the National Park Service *Preservation Briefs* series, National Park Service *Tech Notes* series, U.S. Coast Guard maintenance manuals, and other technical information sources. The bibliography cites the primary sources of information listed by chapter.

For more project-specific questions, a historical architect or engineer should be consulted. The State Historic Preservation Officer can also provide useful guidance and needs to be consulted before the start of any project impacting a historic property as part of Section 106 compliance. (For more information on Section 106, see "Laws and Regulations" under Part I., **Why Preserve Lighthouse?**

How to Use Part IV of this Handbook

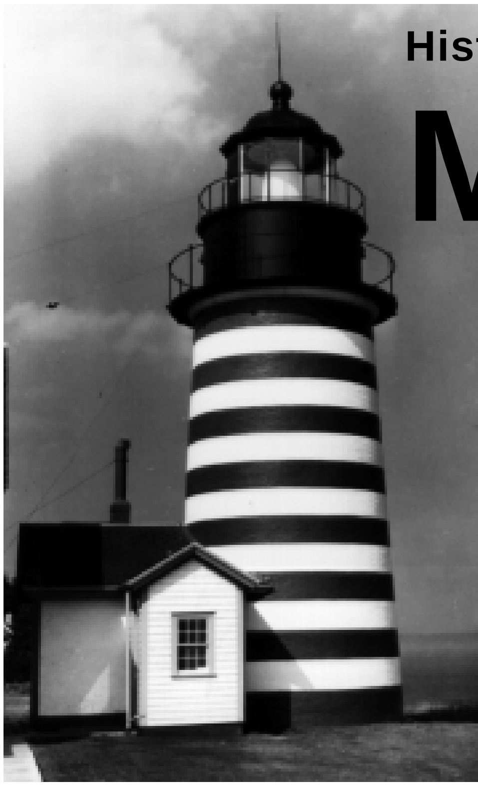
This handbook is lighthouse specific—it does not address all the issues concerning other light station buildings. The information in Part IV is designed to be referenced in both a general and specific fashion. When planning a preservation treatment for a lighthouse, refer to the sections relating to construction type, i.e., masonry, iron, wood, or concrete. In addition to information relating to treatments of specific construction types, the text will guide you through an inspection procedure. The inspection will more than likely indicate problems not specific to construction type. Refer to the sections on windows, doors, lanterns, interiors, and grounds for guidance on these components.

General guidelines for both protection/ stabilization (mothballing) and repair treatments are given for lighthouse construction types and components. As stated in Part III., protection and stabilization is an interim treatment to prevent a lighthouse from further decay until resources are available for a more extensive preservation treatment. With this in mind, protection and stabilization in the following sections should be considered as temporary fixes or "band aids" to keep deterioration in check for a limited period of time. The repair treatments outlined in the following sections are designed to be used a guide for actions taken to correct deteriorated and/or damaged components of historic lighthouses. All guidance is intended to assist the lighthouse manager in putting together a comprehensive long-term preservation treatment plan for his or her lighthouse with maximum retention of historic fabric.

For treatments that go beyond basic preservation, refer to the case studies in Part V., **Beyond Basic Preservation**.

Historic Lighthouse Preservation:

MASONRY



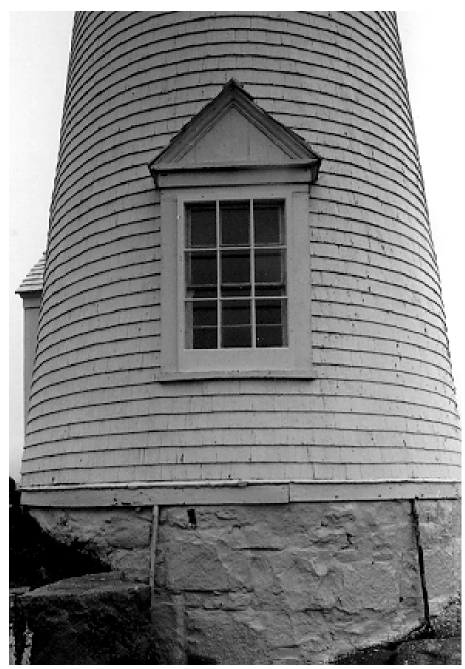
USCG photo

Figure 1. West Quoddy Head Lighthouse near Lubec, Maine

Brick and stone masonry is the most commonly used building material in lighthouse construction.[1] Because of the harsh conditions associated with the locations of most lighthouses, brick and stone masonry was chosen for its durability. The use of masonry construction ranges from stone foundations of wood frame towers to the brick walls of tall towers (see Figures 2 and 4).

The brick or stone used in lighthouse construction was typically quarried (in the case of stone) or made (in the case of bricks) as close to the site as possible. If the raw materials were not readily available, they would be shipped to the site.

The quality of the materials used for lighthouse construction varied. In some lighthouses soft bricks or stones were used. These materials tended to be susceptible to



WPTC photo

Figure 2. Stone masonry foundation in a 38-foot-tall wood-frame lighthouse in Maine.

[1] Brick and stone are typically referred to as masonry construction. Because of the similarities in their preservation treatment, brick and stone are being grouped together. Concrete, which is sometimes referred to as masonry, requires different preservation treatment and will be discussed separately.

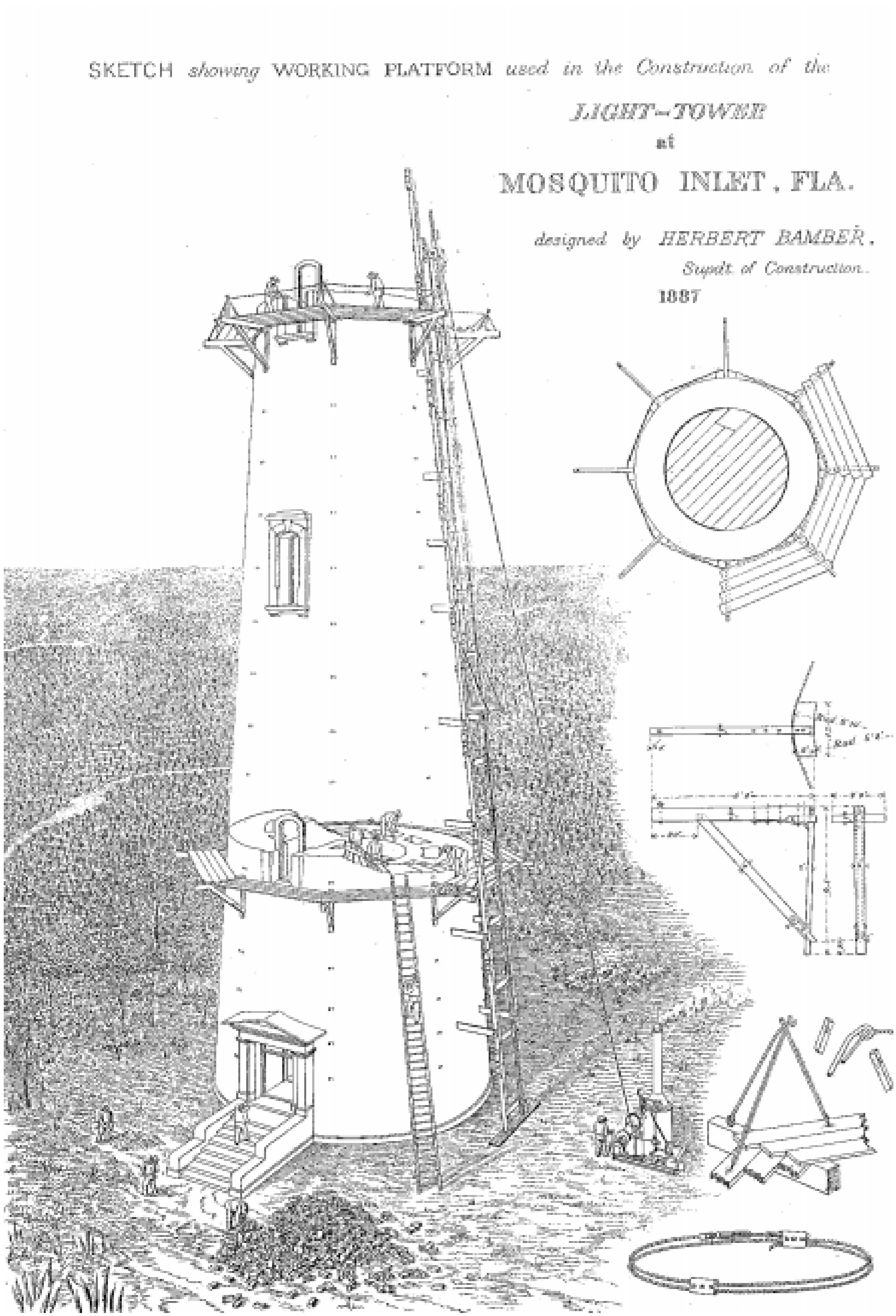


Figure 3. This construction drawing for Mosquito Inlet Lighthouse, Florida, shows the voids or cavities in the walls of tall masonry towers.

accelerated deterioration; therefore they were painted or covered with stucco for protection. This treatment not only provided protection for the lighthouse but also gave the lighthouse a distinct patterning or daymark—characteristics which should be preserved.

In some instances the vulnerable, softer masonry surfaces were not covered with a protective coating, or the protective coating was not maintained and the masonry has since deteriorated. In these cases the protective coating needs to be reinstalled after the required repairs are made, or the masonry may need to be consolidated by a qualified architectural conservator.

Masonry lighthouses are typically constructed in one of two configurations: solid wall or hollow cavity wall. Shorter towers tend to be solid-wall construction because the cross section of wall can be thin enough to support the lantern and interior stairs as well as economical to build. Tall towers are typically constructed with radiating cavities or voids. The exterior of the tower is the frustum of a cone while the interior is typically a cylinder. From the cylinder are radiating walls that tie into the exterior walls and create voids or cavities. The voids in the wall structure save weight while at the same time do not compromise the strength of the wall. The voids are typically vented to encourage air movement through the internal cavities. This ventilation system should be preserved and maintained.

WPTC photo

Figure 4. Brick masonry construction in the 171-foot-tall Pensacola Lighthouse in Florida.

Bender & Associates, Architects

Figure 5. The coating that once protected the soft bricks of this lighthouse was not maintained; the severe deterioration required the replacement of nearly 25,000 bricks.

Masonry features (such as brick cornices and door pediments, stone window architraves) as well as masonry surfaces (modeling, tooling, bonding patterns, joint size, texture, and color) are usually important in defining the historic character of the lighthouse. The character-defining features should be retained during any treatment. While masonry is among the most durable of historic building materials, it is also susceptible to damage by improper maintenance or repair techniques and by harsh or abrasive cleaning methods. Therefore, all treatments should be executed using the gentlest means possible.

WPTC photo

Figure 6. The once crisp edges of this decorative granite lintel have been eroded by constant high winds and airborne sand.

Why Does Masonry Deteriorate?

Brick and stone are subject to attack by a host of forces. The success of a lighthouse resisting these pressures depends on how well it was designed, constructed, and maintained. A well-built lighthouse may withstand damage indefinitely. Lighthouses with weak foundations and parts that do not shed water or absorb movement, and those made of inferior brick or stone, will deteriorate at an increased rate.

The leading causes of deterioration are

- excessive moisture within the masonry that gives rise to the destructive crystallization action of soluble salts as well as freeze-and-thaw expansion-and-contraction action in northern climates;
- water flowing through walls which can lead to differential settlement, deterioration of adjacent materials (rusting iron anchors or rotting window lintels, for instance), washing out of internal bonding and mortar, and other structural problems;
- inappropriate rehabilitation techniques such as sandblasting; and
- use of mortars that have a high compressive strength, i.e., are harder than the brick or stone.

Secondary factors are

- abrasion by the wind and wind-born solids;
- differential expansion that places internal stresses on the lighthouse when one part responds to thermal stresses more than another or;
- uneven settlement when a lighthouse shifts because of weaknesses in the soil, foundations, or structure;
- mechanical impact caused by accidents, wear and tear by users, or some renovation techniques such as installation of aids to navigation equipment;
- chemical disintegration caused by pollutants in the atmosphere; and
- inadequate ventilation that causes a buildup of moisture on the inside of the tower.
- coating of internal walls with impermeable paint that does not allow moisture to escape.

Inspecting for Masonry Problems

In order to develop an effective treatment plan for masonry problems, an in-depth inspection must be made of the lighthouse and its immediate surroundings. The following chart, derived from *Masonry: How to Care for Historic Brick and Stone* (Mark London, Preservation Press, 1988), is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Masonry Lighthouses	
THE SITE	
Look For:	*Possible Problems:*
Environment	
Typical climatic conditions, including average temperatures, wind speeds and directions, humidity levels, average snow accumulation, ice, wave action, salt spray, and blown sand	Severe conditions can lead to masonry deterioration, including cracking, spalling, surface erosion, and efflorescence. Masonry lighthouse features can be broken or damaged by the weight of excessive ice build-up or by the impact of violent wave action or wave-carried debris.
Number of freeze-thaw cycles	Severe cycles can produce damage from frost action if moisture is trapped in walls or there is a lack of total structure ventilation. Daily freeze-thaw cycles may also cause excessive condensation build-up within the tower that may promote fungal growth and rot as well as cause iron components such as stairs, landings, and hatches to rust and deteriorate.
Location near sea	Salt in the air can lead to efflorescence forming on the masonry.
Acid rain in the region from nearby industry or from automobile exhaust	Acid rain can cause damage to limestone, marble, sandstone, and concrete.
Proximity to a major road, highway, railroad, or airport	Excessive vibrations can be harmful to mortar joints and other lighthouse parts.
Location in the flood plain of a river, lake, or sea	Prolonged immersion in floodwaters can cause moisture damage to foundations and walls.
Exposed or sheltered locations/elements of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration. Portions of the lighthouse that do not receive sunlight are susceptible to mildew and other forms of biological attack.

Look For:	*Possible Problems:*
Terrain	
Soil type—clay, sand, rock	The type of soil influences water drainage around the structure. Excessive water in the soil can cause rising damp, leading to structural problems.
Slope away from lighthouse on all sides	If no slope exists, puddles will form at the base of the lighthouse during heavy rains. This may lead to localized ground saturation and water penetration. Localized ground saturation may cause soil around the lighthouse to shift, possibly resulting in uneven settlement.
Earth covering part of a brick or stone wall or foundation	Moisture accumulation or penetration is possible.
Asphalt or other impervious paving touching the lighthouse foundation (if exposed) or walls	Detrimental water accumulation and rain splash-back onto the walls can result. Splash-back can wash mortar out of the joints as well as saturate the masonry causing premature failure of exterior coatings (if present).
Trees and Vegetation	
Species of trees within 50 feet of lighthouse Elms and some poplars dry up clay soil, possibly leading to foundation failure.	Branches rubbing against a wall or roof Branches may abrade surfaces
Ivy or creepers on walls	Leaves prevent proper drying of the masonry surface. Tendrils from some species can penetrate mortar joints, ultimately leading to erosion of the mortar joints and possibly dislodging the brick or stone.
THE LIGHTHOUSE	
Exterior Walls	
General state of maintenance and repair	A well maintained lighthouse should require fewer major repairs.
Evidence of previous fire or flooding	Such damage may have weakened structure members or caused excessive moisture.
Signs of settlement such as cracks and sloped or wavy mortar joints.	These indicate previous water movement. The resulting cracks can allow water to enter the lighthouse walls.
Construction method—solid or cavity wall	Knowing how a tower wall is constructed will help in analyzing problems and selecting appropriate treatments.

Look For:	*Possible Problems:*
Embedded iron (steel) anchors, structural members, etc.	As iron (steel) rusts, it expands; this expansion can damage the surrounding masonry.
Evidence that parts of the lighthouse were constructed at different times or of different materials	Similar problems with various parts may need different treatments because of different materials.
Weep holes—small holes at the bottom and top of walls	Holes allow ventilation from the air space in a cavity wall. The holes should be clear to allow for ventilation. If missing, they can be added during rehabilitation.
Attached antennas, range finders, auxiliary or replacement lights, etc.	Heavy devices which are cantilevered off the side of the tower wall may cause eccentric loading. If this load is improperly distributed, severe cracking and possible localized failure (i.e., blowout) may result.
Bulges	Bulges indicate that the wall has moved and corrective action may be necessary.
Outer-face bulge	Solid walls tolerate movement less if only the outer face is moving; immediate remedial action may be necessary.
Cracks	Cracks indicate movement has occured within the wall. Small cracks may be patched; large cracks may require reconstruction of the affected area.
Enlarging cracks	Active cracks indicate a continuing problem. The cause must be dealt with before the crack itself is repaired.
Consistent wall plane	A crooked or skewed wall indicates movement has occurred and may still be occurring. This condition should be monitored to determine whether the movement is continuing and the lighthouse is in danger of collapsing.
Windows and Doors	
Straight and square openings	Deformed openings may indicate uneven structure settlement or failure of concealed structural members, i.e., wood lintels.
Sills sloped to shed water; drips under sills to prevent water from running back underneath; caulking	If any of these is inadequate, water can penetrate into the lighthouse wall.
Sealed window and door frames	If caulking is missing or deteriorated around window and door frames, moisture can pentrate into the wall cavity and cause deterioration of the window or door frame as well as of the masonry.

Look for:	*Possible Problems:*
Foundation	
Uneven settlement	This may cause the leaning tower effect and possibly result in collapse of the lighthouse.
Composition of foundation walls	Stone or brick is more likely than concrete to allow water to infiltrate.
Damp proof course	This will impede rising damp, lessening deterioration of the masonry wall. If work is performed on the wall, the integrity of the damp proof course must be maintained.
Rising damp—discoloration along wall in approximate horizontal line	Could indicate serious foundation or drainage problem.
Interior	
Cracked plaster, signs of patching, stairs and landings askew	These may be signs of lighthouse settlement.
Damp walls, mold or mildew stains on walls, efflorescense, 'bubbling' or blistering plaster, rotting wood	These indicate water infiltration or severe condensation or moisture buildup within the lighthouse.
Masonry Components	
Materials	
Composition, including secondary materials; characteristics—color and color variation; texture—smooth or patterned surfaces	Types of materials indicate the susceptibility to damage and should be matched if the masonry component is repaired or replaced.
Areas of delicate carving or fine moldings such as decorated entry ways or window surrounds	These sections may need special attention or protection during rehabilitation.
Missing or broken bricks or stones	Missing material may allow water penetration, as well as indicate movement of the structure.
Evidence of sandblasting, such as a pitted surface; evidence of erosion, crumbling, flaking, scaling, or spalling	Sandblasting can remove the outer hard-baked protective surface of the brick making the inner softer core vulnerable to moisture penetration. Sandblasted bricks are not only aesthetically displeasing, but may be a point of moisture infiltration as well.
Dirt or stains	Surface stains usually cause few problems other than being unpleasant to look at. Streaking on the surface of the lighthouse tower, however, may be an indicator of deteriorating materials that are not readily visible, such as rust streaks from embedded iron anchors, etc.

Look for:	*Possible Problems:*
Moisture	
Water penetration through joints between masonry and other lighthouse components, through masonry joints or, rarely, through brick or stone units	Moisture can lead to deterioration of the masonry and other parts of the lighthouse.
Staining or white deposits (efflorescence), mold and mildew stains on walls	White deposits are evidence of excessive dampness. Efflorescence on most new or newly repointed walls (new construction 'bloom'), however, is natural and will disappear after normal weathering.
Location and type of salt deposits on surface; or standing water	Deposits can indicate a source of dampness, such as rainwater or ground water, inside the lighthouse materials.
Moisture buildup or condensation on interior window panes	Indicates high moisture levels and poor ventilation.
Coatings	
Applied coating type: stucco, lime mortar wash	Stucco and lime mortar wash are common lighthouse coatings. Applied stucco surfaces should be inspected for cracks that could allow water infiltration. Lime mortar wash or whitewash is considered a sacrficial coating. The lime mortar wash protects the lighthouse masonry by wearing away over time. This coating is meant to be reapplied periodically like paint.
Paint; type of paint	Paints and other coatings are designed with a specific permeability rating. A paint or coating with a low permeability rating may trap moisture and cause masonry to spall or the coating to blister.
Blistering, flaking and peeling paint (interior or exterior), failure of plaster or stucco	These conditions indicate there is an excessive amount of moisture within the masonry substrate. Escaping moisture literally pushes the paint film off the masonry. The amount of moisture transpiration may exceed the permeability of some coatings, therefore even coatings that 'breathe' may fail if the moisture content of the substrate is high enough.
Waterproof or water repellent coating	Such coatings often trap moisture within the masonry.

Look for:	*Possible Problems:*
Mortar Joints	
Type of mortar used during the original construction of the lighthouse—lime based, usually whitish; or portland cement, grayish and very hard	A portland based cement mortar may be too hard for certain masonry bricks and can lead to cracking or other damage of the brick or stone units. Replacement mortar should be compatible with the compressive strength of the masonry units.
Condition of mortar—crumbling, eroded, missing	Crumbling mortar may be an indicator that the original mortar mix was made with salt water or salt water contaminated sand (vs. potable water and clean sand). If this condition exists the lighhouse may require a comprehensive inspection and repointing with a mortar that matches the compressive strength of the brick or stone. Damaged or missing mortar can allow moisture to penetrate; repointing may be required. This condition may also lead to differential settling, eccentric loading, cracking or displacement of masonry, and/or the possible failure of load bearing wall sections.
Broken or chipped edges of brick or stone along joints	Damage may indicate mortar in joint is too hard.
Chimneys and Other Openings	
Boarded or closed openings such as windows, doors, fireplaces, etc.	When removing coverings, personal injury may result from falling debris.
Chimneys, fireplaces, and other types of flues	Different types of soot found in chimneys and other types of flues may cause serious health problems. When inspecting these features of a lighthouse, it is essential to wear personal protective gear such as a respirator, eye protection, and if there is a potential danger of falling debris, a hard hat.

PRESERVATION TREATMENTS

Many of the maintenance and repair techniques described in this text, if not properly performed, can cause potentially irreversible damage to the character-defining features and historic fabric of a masonry lighthouse. Therefore, if the tasks to be performed are beyond the skills of on-site personnel, they should be carried out by experienced and qualified workmen. A historical architect or building conservator may be required to assess the condition of the masonry and prepare contract documents for its treatment. In Part V., **Beyond Basic Preservation**, examples of treatments that are considered rehabilitation and restoration are illustrated and discussed.

Protection and Stabilization (Mothballing)

Despite their inherent durability, a historic masonry lighthouse that is vacant and receives only minimal routine maintenance is highly vulnerable to decay if not protected and stabilized properly. To properly protect and stabilize a historic masonry lighthouse, a thorough inspection and diagnosis should be performed using the inspection chart in the preceding section as a guide. The results of this inspection can then be used to develop a protection and stabilization plan. The following recommended protection and stabilization guidelines for vacant historic masonry lighthouses are the minimum treatment requirements to prevent any further damage from occurring.

Weatherization

When a masonry lighthouse is mothballed, the exterior envelope should be completely weathertight. When moisture penetrates into masonry walls and foundations, it can be exceedingly detrimental to the masonry. Moisture in a wall or foundation causes various types of damage: it washes away softer lime mortars, expands and cracks surrounding masonry in freezing weather, causes efflorescence (the leaching of salts out of the mortar and masonry units), causes adjacent wood elements to rot, and encourages fungal growth.


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Figure 7. Lantern glass with holes and/or cracks should be replaced as soon as possible to minimize water infiltration. If immediate replacement is not feasible, the glass can be temporarily patched.

To prevent moisture penetration, be sure the following moisture infiltration points are weathertight or functioning properly:

- ***Lantern glass:*** Lantern glass, frames, and roofs must be weathertight before mothballing. Refer to the **Lantern** section of this handbook for more information concerning weatherproofing lantern components.

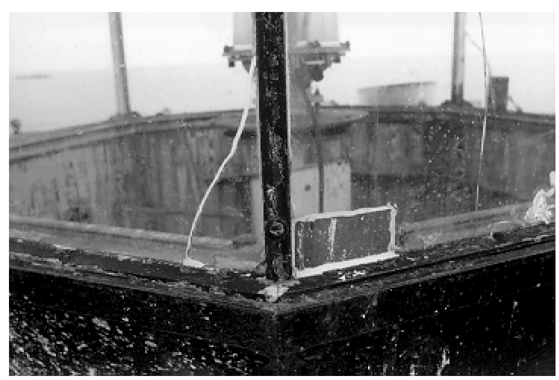
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Figure 8. Detail of an acceptable temporary repair to a lantern glass using a piece of painted sheet metal that has been adhered to the glass with a high quality, exterior grade caulk. This type of temporary repair will prevent water from entering the lantern and therefore help avoid further damage. This fix should be considered only as an interim treatment until replacement of the lantern glass.

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Figure 9. View of built-in gutter system on a mansard-style roof; the arrow indicates where a fist-size hole exists. This hole allows water to enter the interior of the lighthouse.

WPTC photo

Figure 10. View of underside of gallery deck; the streaks on the stucco indicate that water is passing between the deck plates and possibly entering the masonry wall.

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Figure 11. Detail of severely eroded brick and painting.

- ***Built-in gutter systems:*** All rainwater gutter systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. All holes and non-functioning gutter system components should be repaired. For more information refer to the discussion on roofing in the **Lantern** section of the handbook.
- ***Gallery decks:*** In most masonry lighthouses gallery decks are cast iron, sheet-metal-covered wood, stone, or concrete. These decks are generally laid directly on top of the masonry wall structure. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior cavity of the masonry wall. See Figure 10 for signs that a gallery deck is failing. Refer to the **Lantern** section of this handbook for more information concerning the weatherproofing of gallery decks.
- ***Door and window frames:*** The joints along the perimeter of door and windows where a wood or metal frame is fitted into a masonry opening should be caulked to prevent moisture from entering the walls. See the **Windows** section of this handbook for the proper caulk for this application.
- ***Loose or eroded mortar joints:*** If pointing between masonry units is loose, cracked, eroded, or is completely missing, moisture will penetrate (see Figure 11). In order to prevent this infiltration, all pointing that is in disrepair must be removed and the affected joints repointed. For more information refer to the discussion on repointing under the **Repair** treatment in this section of the handbook.
- ***Weep and vent holes:*** If the walls have cavities between the interior and exterior walls, weep holes may exist at or near the base of these walls. Weep holes typically range in size from small slits to large brick headers. These holes allow any moisture that has entered the cavity between the walls to drain out. These openings must be kept clear in order to provide sufficient drainage of the cavity. In some instances the walls may have vent holes (larger than weep holes) that allow the movement of air through the cavities or voids. Typically vent holes open into the interior. These openings must be kept clear in order to provide sufficient ventilation (see Figure 12).
- ***Protective coatings:*** Lighthouses were often painted as a protective measure and for identification as a daymark. As part of a

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Figure 12. Typical masonry lighthouse weep hole locations. Each weep hole provides drainage for each individual cavity within the masonry wall.

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Figure 13. Vent hole located in the window well of a brick lighthouse.

mothballing treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color. Ultimately, as part of a mothballing treatment the entire lighthouse should have all loose and flaking paint removed and a new coating applied according to the manufacturers specifications. If the overall condition of the coating system is sound and there are only a few bare spots, however, the lighthouse can be spot painted to provide a weatherproof coating. Either of these actions will result in a coating

WPTC photo

Figure 14. Detail of failing paint, a problem which should be addressed during stabilization and protection. In this particular case, spot painting may be all that is required to maintain a weatherproof protective coating.

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Figure 15. Cracks such these in a sandstone lighthouse should be monitored for movement prior to treatment.

system that will require minimal service during the mothballed period. For more information refer to the discussion on repainting under the **Repair** treatment in this section of the handbook.

- ***Open cracks in walls:*** Cracks in exterior masonry walls indicate that movement has occurred, either caused by shrinkage (in the case of stucco) or by settlement or mechanical impact. Cracks should be monitored to determine if movement is still occurring and structural stabilization is necessary before the crack is filled. Refer to the following repair section for more information concerning wall repair.

Stabilization

When mothballing a masonry lighthouse, all possible structural repairs should be made before the beginning of the

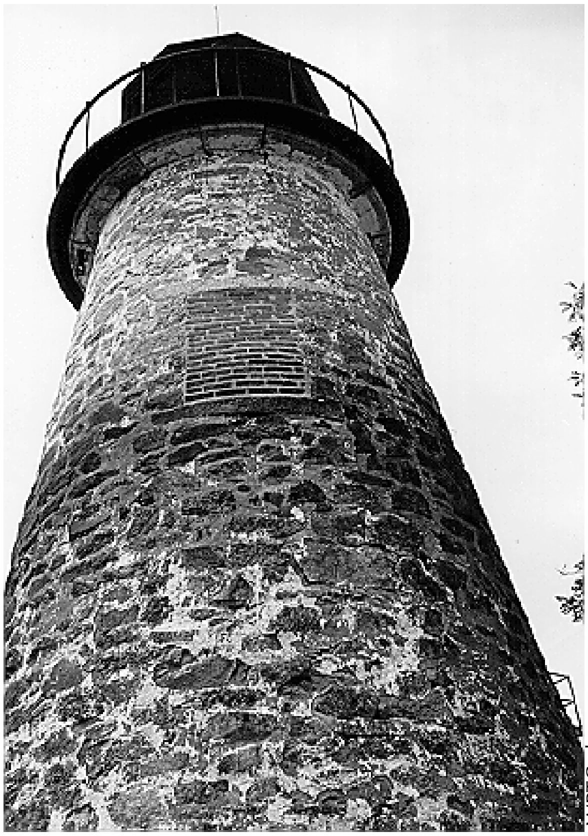

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Figure 16. An example of a reversible masonry stabilization treatment for the window opening that has prevented structural deterioration and moisture infiltration.

'mothballed' period. If funds are insufficient to make structural repairs, structural stabilization should be performed as a less expensive temporary alternative. Temporary blocking in of window and door openings and installation of interior or exterior shoring or bracing are all stabilization methods. Figure 16 illustrates a window opening that has been stabilized with brick infill. Brick is a historic stabilization method in stone masonry construction. If this method is used, the mortar employed should be soft enough to not permanently adhere to the historic masonry, thus making the treatment reversible. Other methods of door or window opening stabilization include fitting the opening with a structural wood frame covered with a painted plywood panel that has large louvers to aid in venting the interior of the lighthouse. The stabilization treatment utilized should not permanently damage historic character-defining features and should be easily reversible so that when the budget allows, the structure can be properly repaired.

Ventilation

The most difficult lighthouses to adequately ventilate without resorting to extensive louvering and/or mechanical exhaust fan systems are masonry lighthouses in humid climates. During the summer months masonry lighthouses will need to be ventilated to eliminate stagnate air and damaging condensation on the interior walls and woodwork. In order to achieve this, almost every window opening will need to be fitted with some type of passive louvered ventilation. Installation of window-mounted passive louver systems is covered in the **Windows** section of this handbook. For more information on lighthouse ventilation refer to the **Interiors** section of this handbook.

Fire Protection

Despite the fact that masonry is noncombustible, fire is still a threat to combustible components of masonry lighthouses. The impacts of a fire are devastating and will often cause serious irreversible damage and loss to historic interior fabric. For guidance on these issues, refer to "Fire Prevention and Protection Objectives" under Part V., **Related Activities**.

Repair

Before any preservation repair work is begun, all masonry features that are important in defining the overall historical character of the lighthouse should be identified. These features include brackets, cornices, window architraves, door pediments, steps and pilasters, joint size and tooling and bonding patterns, coatings color and texture. During all repair work measures should be taken to ensure that these features are not damaged.

Once a thorough inspection and diagnoses is performed, using the inspection chart starting on page 5 as a guide, a treatment plan can be developed using the following basic masonry lighthouse preservation guidelines.

Cleaning

The simple act of cleaning painted masonry surfaces can effectively extend the life of the coating as well as effectively enhance the appearance of a historic masonry lighthouse. In some cases where the masonry has not been painted, a deep cleaning of the porous masonry surfaces is needed. This treatment should be used if a buildup of pollution or salts is causing deterioration to the masonry substrate. The following are guidelines for cleaning historic masonry lighthouses:

- Clean masonry only when necessary to halt deterioration or when heavy soiling must be removed to prevent damage to the masonry.
- Carry out masonry surface cleaning tests after it has been determined that such cleaning is necessary. Do not clean masonry merely to improve appearance.
- Clean masonry surfaces with the gentlest method possible, such as using low pressure water and detergents and natural bristle brushes. To select the gentlest method possible, tests should cover a period of time sufficient to determine both the immediate and long-range effects.
- Always allow for thorough drying time of the masonry (months or possibly years) before proceeding with any sealing of the exterior or interior.
- Always neutralize any chemical treatment.
- Do not sandblast brick or stone surfaces using dry or wet grit or other abrasives. These methods of cleaning permanently erode the surface of the material and greatly accelerate deterioration.
- Do not use a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures.
- Do not clean with chemical products that will damage masonry, such as using acid on limestone or marble or leaving chemicals on masonry surfaces.
- Do not apply high-pressure water-cleaning methods that will damage historic masonry and the mortar joints.

WPTC photo

Figure 17. Deeply eroded brick as a result of sandblasting. The white areas are where electrical components were attached to the wall at the time of sandblasting.

External Coating Systems

Historically, external coatings were relied upon to protect masonry, such as soft brick or stone, that was susceptible to water infiltration. The external coating was the first line of defense against the elements. Typically the coating was either a paint, stucco, or whitewash/lime mortar wash. As part of preserving the lighthouse, all coatings should be maintained.

Each type of coating protects the lighthouse in a slightly different manner. Paint provides a film over the masonry that prevents water from penetrating. Stucco is a three-layer mortar and sand shell that bonds to the masonry to prevent water from penetrating. Whitewash and lime mortar wash are lime and water based "sacrificial" coatings that protect the lighthouse by slowly deteriorating as they weather.

Lime mortar wash is typically a three-layer coating. The first coat consists of lime, water, and sand; the second, half as much sand; the third, just lime and water. Whitewash is lime and water only. Both of these coatings are meant to be reapplied every three to five years. More information on this coating and its application can be found in the Cape Florida Lighthouse sidebar on page 23.

The key to the preservation of an external coating system, especially a lighthouse coating that is subjected to severe marine environment conditions, is a thorough study of the mechanics of the system. Whether simply touching-up the coating or following through with a complete restoration of the external coatings, it is wise to seek the advice of paint manufacturers' technical representatives.

A thorough study of materials is recommended before starting any coating program. An understanding of the substrate, or base material, must also be had. This can best be achieved by a thorough inspection of both the substrate and the existing coating system. Any areas of deteriorated substrate should be examined and repaired before recoating.

Coatings applied to masonry surfaces should 'breathe', i.e., the coating should allow the transpiration of moisture at the microscopic level. Modern paint coatings are able to do this. A successful coating system for masonry surfaces is an elastomeric acrylic paint system for the exterior surfaces and a breathable acrylic emulsion paint system for the interior surfaces.

All external coatings, especially paints which may date from the 19th and early 20th century, should be tested for lead content. If lead is present, local codes on health, life safety, and environmental requirements must be met.

Lead found in otherwise sound paint layers does not dictate the removal of that paint. In most cases it is far safer and more cost-effective to leave intact paint areas in place. For further information refer to NPS *Preservation Briefs 37: Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing*.

Follow the manufacturer's specifications for surface preparation and application of paint. This will ensure the coating will perform as designed. For more information on types of masonry paints currently being used in the field, refer to the case study on Point Conception Light Station in Part V., **Beyond Basic Preservation**.

The following guidelines are to be followed when recoating historic masonry lighthouses.

- Before recoating, inspect all painted masonry surfaces to determine whether repainting is necessary. If painting is the determined treatment, a schedule of colors, locations, and quantities should be developed.

- Remove damaged or deteriorated material only to the next sound layer, using the gentlest method possible (e.g., hand scraping) before recoating.
- Recoat surfaces with a system designed for the masonry substrate—brick, stone, or stucco. The system should be designed to 'breathe' so that moisture trapped within the masonry units can escape. This quality is referred to as the permeability of the coating system.
- Use colors that are historically appropriate to the lighthouse or that maintain the character-defining features of the daymark.
- Do not remove any coating that is firmly adhering to, and thus protecting, masonry surfaces.
- Do not use methods of removing coatings which are destructive to masonry, such as sandblasting, application of caustic solutions, or high-pressure water blasting.
- Do not apply coatings such as stucco to masonry that historically has been unpainted or uncoated.

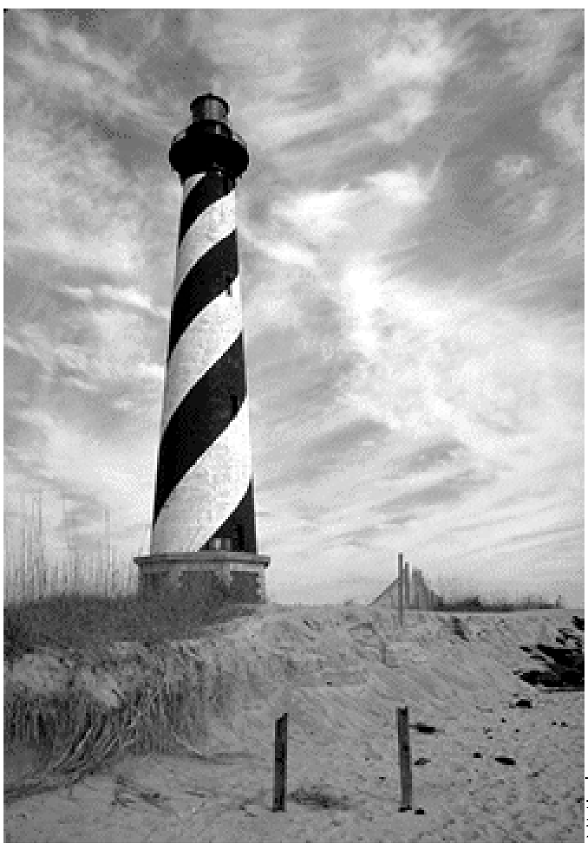
NMI photo

Figure 16. Daymark patterns are a character-defining feature and should be preserved.

- Do not remove historic masonry coatings and leave the underlying layer exposed to the elements.
- Do not apply a sealing type paint to the interior of a lighthouse. This will potentially trap moisture in the wall which will cause the wall to deteriorate.

Repointing

Repointing is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar. Properly done, repointing (also called, somewhat incorrectly, tuck pointing) restores the visual, physical, and structural integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may in fact cause physical damage to the masonry units and the overall structure.

Mortar joints bind together the individual masonry elements of a wall into a structural whole, ensuring a watertight seal. The mortar bed compensates for irregularities in the stones or bricks, which would otherwise lead to uneven stresses and cracking of the masonry unit. The more regular the stone or brick, the thinner the joint can be.

A wall made up of many small units such as brick or stone is both easy to construct and absorbs inevitable slight movements, including variations in temperature, settlement of the building, and vibrations. To absorb these movements, the mortar joints must be somewhat weaker than the masonry units to allow for compressive loading. If a mortar is used which is high in compressive strength (i.e., portland cement), the masonry units become the weakest part of the wall, and slight movements can cause the brick or stone to crack or spall. As mortars become stronger, they tend to become more impermeable to moisture than the masonry units and thus prevent drying through the joints. Moisture movement then is concentrated in the brick or stone, leading to damage of the masonry structure.

Unlike most other parts of a lighthouse, mortar joints are not designed to be permanent, although a good pointing job should last 50 to 100 years. When the time comes to repoint, shortcuts and poor craftsmanship will result in a job that needs to be done soon again or, in the worst case, in a structural failure.

When repointing joints in historic lighthouses, special care must be given to the matching of the strength of the replacement pointing mortar with that of the original pointing mortar. Historically, softer lime-based mortars were used for pointing. If the compressive strength of the original mortar cannot be readily determined, i.e., the lighthouse had been improperly repointed with a hard portland cement based mortar, the mortar should be matched to the compressive strength of the brick on stone. For more information on repointing historic lighthouses refer to NPS *Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings.* These softer mortars were flexible enough to expand and contract with the expansion and contraction of the masonry units which made up the wall structure.

WPTC photo

Figure 19. The use of hard portland cement mortar and sloppy pointing technique have aided in the deterioration of this soft sandstone wall.

Modern portland cement has a higher compressive strength than the lime-based mortars. This quality makes the portland-based cements less flexible than the lime-based mortars; therefore, the pointing tends to resist the expansion and contraction of the softer historic bricks. This resistance will ultimately cause the faces of the bricks to fracture and spall off the body of the brick. In some cases the exterior wythes of brick may shear from the inner core of the wall, resulting in the failure of the outer sections of the wall.

Before repointing, a thorough inspection of the masonry should made to determine the extent of repointing needed. Pointing that

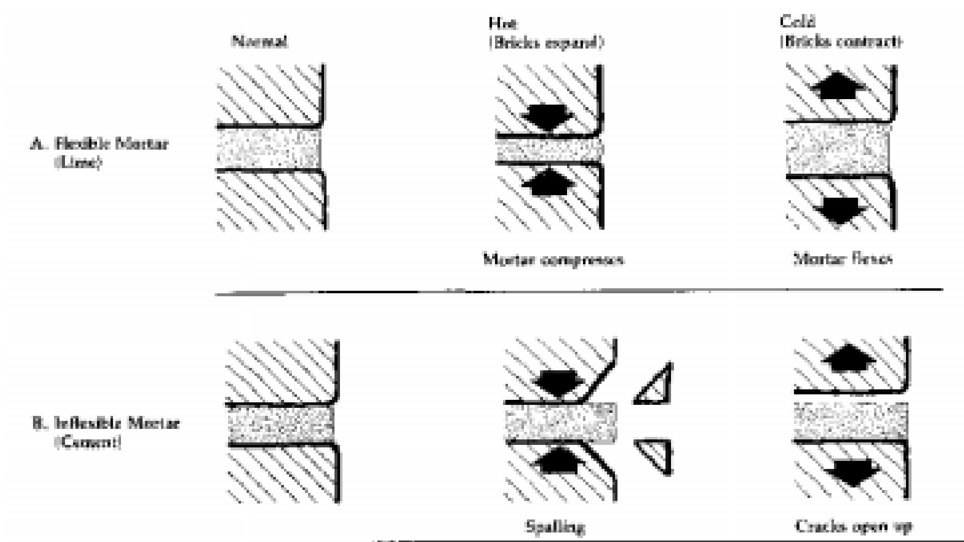

Figure 20. Diagram showing the behavior of lime-based mortar and cement-based mortar during relative temperature changes of the surrounding masonry. (Source: NPS *Preservation Briefs 2*, 1980)

is in need of repair shows signs of deterioration such as disintegrating mortar, cracks in mortar joints, loose bricks, or damp walls. The following are guidelines that should be followed when repointing masonry in historic lighthouses.

- Remove deteriorated mortar by carefully hand raking the joints to avoid damaging the masonry.
- Consider leaving the intact portland cement pointing in place because removal may damage the masonry.
- Duplicate the historic mortar in strength, composition, color, and texture. A mortar analysis can be performed by most preservation professionals.
- Duplicate old mortar joints in width and in joint profile.
- Do not remove non-deteriorated mortar from sound joints for purely cosmetic reasons.
- Do not use electric saws and hammers rather than hand tools to remove deteriorated mortar from joints prior to repainting.
- Do not repoint with mortar of high portland-cement content (unless it is the same content of the historic mortar). This can often create a bond that is stronger than the historic material and cause damage resulting from the differing coefficient of expansion and the differing porosity of the material and the mortar.
- Do not repoint with a synthetic caulking compound.

Damaged Masonry Repair

Repair of damaged masonry features can be performed in a variety of ways. Repairing masonry features by patching, piecing in, replacement in kind, or consolidating the masonry using recognized preservation methods is a task best performed by

WPTC photo

Figure 21. Detail of eroded pointing.

WPTC photo

Figure 22. A failing repair made to a stone gallery deck using a simulated stone material. A stone dutchman repair should have been used.

professionals specializing in such work. The following are general guidelines to consider when repairing historic masonry.

- Repair only damaged materials. If possible, limit this type of work to replacement of damaged masonry units only, i.e., isolated removal of a single damaged brick or stone.
- When repairing stone, use traditional dutchman repair techniques as a first choice; consider substitute materials only as a last resort.
- For replacement, use only substitute materials that convey the visual appearance of the surviving parts of the masonry feature and that are physically and chemically compatible.
- Do not apply waterproof, water-repellent, or non-historic coatings such as stucco to masonry as a substitute for repainting and masonry repairs. Coatings are frequently unnecessary, expensive, and may change the appearance of historic masonry as well as accelerate its deterioration.

Stucco

Stucco is an exterior plaster which has historically been used to weatherproof and in some cases decorate masonry lighthouse exteriors. Although stucco is nonstructural, it offers a protective coating and prolongs the life of a lighthouse. Stucco is both convenient and affordable: its ingredients are readily available; it can be readily applied over stone or brick; and it is repairable when cracked or broken.

The choice of materials for the aggregate and binder is critical to match an existing stuccoed surface. Stucco is an inexpensive material that forms a resistant exterior shell to protect *more* costly and vulnerable materials, i.e., soft bricks or stone, in the substrate from exposure and decay; it may considerably prolong the life of a masonry lighthouse by sheltering major components from wear. Also, though stucco application requires a skilled worker, only a minimal amount of specialized equipment is necessary.

Stucco failure is caused by the breakdown of the its water-shedding capacity and the ultimate deterioration of the supporting structure. Poor original materials and techniques, incompatible building materials with different expansion rates, structural settlement, *seismic* movement, and biological growth can all cause cracking or adhesion failure between the stucco and its backing or between individual stucco layers. Lack of proper maintenance increases the likelihood of problems that can lead to the breakdown of the stucco skin.

An aggregate and a binder are the two basic stucco constituents. The aggregate consists of a fine granular substance—such as crushed sea shells, crushed brick and stone, sand, or old mortar—while traditional binders include lime, gypsum, or natural and manmade (portland) cements. In addition, mineral pigments can be added for color and synthetic additives used to further improve the performance of the stucco mixture.

A mechanical key must be created to ensure a strong bond between the stucco and its support. For masonry, either raking out the mortar joints or texturing the masonry surface is usually necessary. Generally, stucco is applied in one to three coats; three-coat work is most common. Layers usually differ slightly in composition, and each coat is scored to provide a key for the next layer.

Although the earliest stuccoes used lime as a binder, by the middle of the 19th century stucco included other elements such as imported natural cement. Gray portland cement stucco, harder and denser than earlier stuccoes, appeared in the 1880s; with the introduction of white portland cement in the early 20th century, a range of tinted stuccoes became available.

The following are guidelines to consider when repairing historic stucco:

Identify, retain, and preserve stucco coatings that are important in defining the overall historic character of the building.

- Determine whether the historic finish coat of stucco was painted, unpainted, or integrally colored.
- When repairing stucco, identify original components of the stucco mix through laboratory analysis to match strength, composition, color, and texture.
- Identify substrate and method of keying stucco to the underlying structure.
- Identify finish trowelling techniques to duplicate the original finish in replacement stucco.
- Do not remove stucco from surfaces that historically featured a stucco finish.
- Do not remove and reapply a major portion of a stucco coating that could be repaired.
- Do not apply paint to stucco that has been historically unpainted or, conversely, remove paint from historically painted stucco.

Maintain:

- Maintain lantern roofs, gutters, and gallery decks to prevent moisture from penetrating walls.
- Remove all plant materials from the base of stuccoed lighthouse walls.
- Survey stucco surfaces for conditions such as biological growth, water or metallic staining, or leaching deposits, which may indicate active water penetration or damage that is masked by the stucco coat.
- Determine the extent of detached stucco by systematically sounding the surface with a wood or acrylic mallet. Areas where stucco layers have delaminated or are no longer keyed to the substrate will produce a characteristic reverberating or hollow sound and should be repaired as outlined below.

Clean stucco only when necessary to halt deterioration. It is difficult to clean most stucco without also removing some of the textured surface. Test cleaning methods in a discreet location before full-scale treatment. The gentlest method should be selected and tested to avoid unnecessary damage.

- Remove soiling and biological growth, such as mold, using a low-pressure water rinse and mild detergent applied with natural fiber brushes. Poultice-applied solvents are probably the most appropriate method for removing graffiti and metallic stains.
- Do not use abrasive cleaning techniques on stuccoed surfaces, which can pit the surface and increase moisture penetration.
- Remove damaged or deteriorated paint from stucco only to the next sound layer using the gentlest method possible, such as hand-scraping or natural bristle brushes.
- Maintain paint coatings by applying a vapor-permeable coating when necessary, matched to existing color.

Repair most stucco by removing damaged material and patching with new stucco that duplicates the old in strength, composition, color, and texture.

- Repair cracks in stuccoed surfaces by raking out the crack and undercutting the edges to provide a mechanical key for new stucco. Cracks are most likely to occur at doors, windows, and where stucco covers joints between dissimilar masonry materials, i.e., brick and stone.
- Do not insert a metal lath over masonry. Attaching the lath will damage the masonry; moisture penetration can cause the metal lath and attachments to corrode.
- Do not apply a stucco patch without remedying the underlying problem.
- Remove incipient spalls or bulges back to sound plaster. Identify and rectify the cause of deterioration before patching.
- Remove previous patches that do not match texture, color, or strength of the original stucco.
- Undercut the repair boundaries to create a dovetail-shaped mechanical bond between the old and new stucco.
- Test new stucco in an inconspicuous location and allow test samples to weather as long as possible, ideally for one year. Matching the original material will probably require a number of test samples.

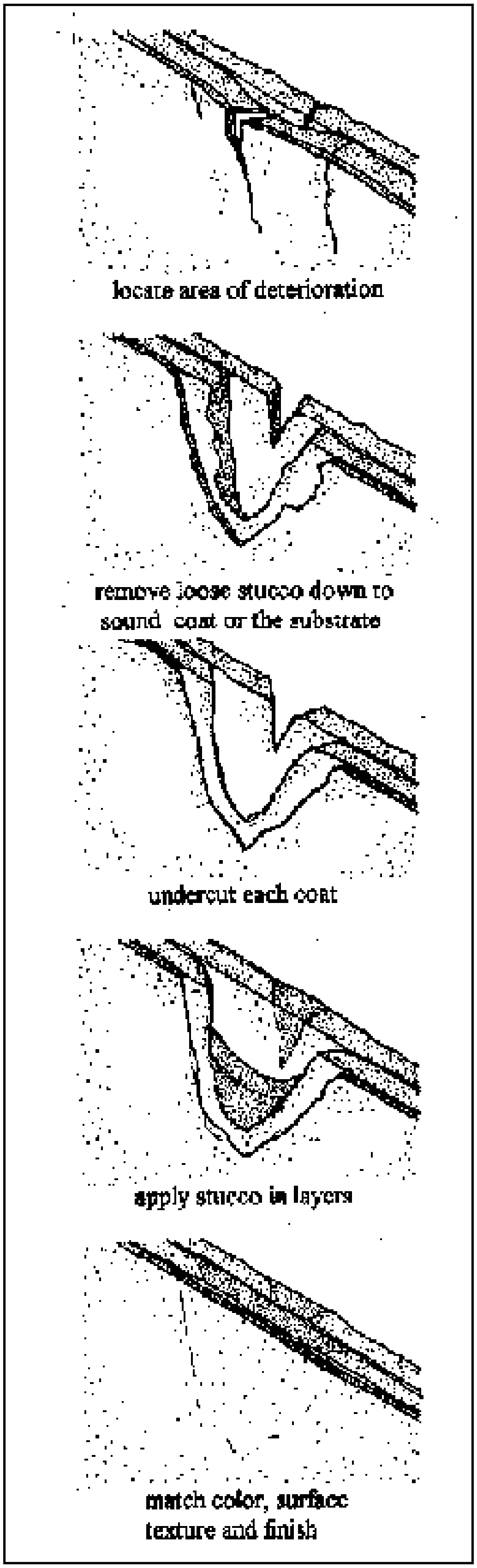

Figure 23. The five basic steps of stucco repair; each layer of stucco must be patched separately. (NPS drawing)

- Do not remove sound stucco or use new stucco which is stronger or denser than the historic material. Doing so will damage underlying masonry as well as alter the appearance.
- Patch stucco rather than replace. It is difficult to match stucco and to conceal patched areas, especially on smooth-finished stucco. A color match may not be critical if the surface was originally painted and will be repainted following repairs.
- Thoroughly wet the substrate before patching to prevent it from drawing moisture out of the stucco too rapidly which could affect the curing time and eventual strength.
- Do not patch cracks with commercial caulking compounds. This type of patch is highly visible because the material has a different texture and sheen than stucco. It also tends to attract dirt and weathers differently.
- Do not apply new stucco when there is danger of frost, or in temperatures below 40° F.
- When applying stucco, provide adequate separation from the ground. Moisture from the ground can rise through the stucco and into the supporting structure.
- Do not apply paint to repair patches before the new stucco has fully cured.
- Do not apply a bonding agent where a mechanical bond is possible. A good mechanical bond is always preferable to reliance on bonding agents. Only substrates that do not offer a good bonding surface may require the use of a bonding agent.
- Prevent new stucco from drying too rapidly during hot weather by shading or repeated misting for 48 to 72 hours.
- Reintegrate detached or delaminated stucco by low pressure injection grouting with fluid mortars or synthetic adhesive materials. These substances must be compatible with the original stucco. This treatment is generally appropriate only for decorative stucco that may be difficult to replicate. The work should be executed under the supervision of a qualified preservation maintenance professional.
- Use chemical consolidants on deteriorated stucco only when deemed necessary by a trained conservator. The need for this type of treatment on most stucco-covered lighthouses is limited. Materials and methods must be tested

before attempting full-scale treatment; different stuccoes may require different consolidation materials for chemical compatibility.

Limited Replacement In kind

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the *limited replacement in kind* of extensively deteriorated or missing *parts* of features when there are surviving prototypes (for example brick cornices and door pediments, stone window architraves, wall structure masonry units). The replacement material needs to match the old both physically and visually, i.e., sandstone for sandstone or dark red, hard-fired brick for dark red, hard-fired brick, etc. Thus, with the exception of hidden structural reinforcement and new mechanical system components, substitute materials are not appropriate in the preservation treatment. Again, it is important that all new material be identified and properly documented for future research.

If prominent features are missing, such as formal stone or brick entry stairs or interior decorative brick or marble floors, then a rehabilitation or restoration treatment may be more appropriate.

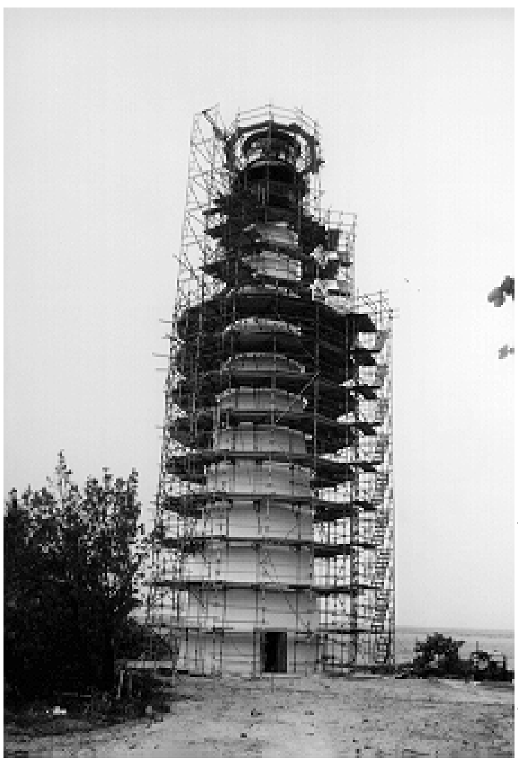

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Figure 24. Cape Florida Lighthouse with scaffolding used during the 1996 restoration. The white coating on the tower is the lime mortar wash applied to help protect the damaged brick and to restore the tower to its 1846 appearance.

SIDEBAR: Brick Replacement and Coating of Cape Florida Lighthouse

The original Cape Florida Lighthouse on Key Biscayne, Florida, was built in 1825 to a height of 65 feet. The tower wall was constructed with a solid brick wall five feet thick at the base and tapering to two feet at the top. The present Cape Florida Lighthouse was constructed around 1846 with a four-feet-thick brick masonry wall at the base. To meet the aid-to-navigation needs, in 1855 the tower's height was raised to 95 feet with a focal plane at 100 feet above sea level. From 1869 until the light was discontinued in 1878, the lighthouse received numerous repairs.

After 1878, the lighthouse began deteriorating because of lack of maintenance. It was restored and the foundation upgraded in 1915 and 1918 respectively. The deterioration was reinitiated when a hurricane in 1926 eroded the tip of the Cape, increasing the vulnerability of the tower to further decay and deterioration. In 1966 when the state of Florida acquired the lighthouse, a four-year renovation effort was instituted for the entire station. During this time a replica of the keepers quarters and a new lantern was constructed.

Figure 25. View of the lower portion of the tower showing the more severe deterioration. Note that a large percentage of the first brick wythe is missing or has been removed. The white areas are remains of a portland-cement-based parging applied in the late 1960s in an effort to protect the deteriorating bricks.

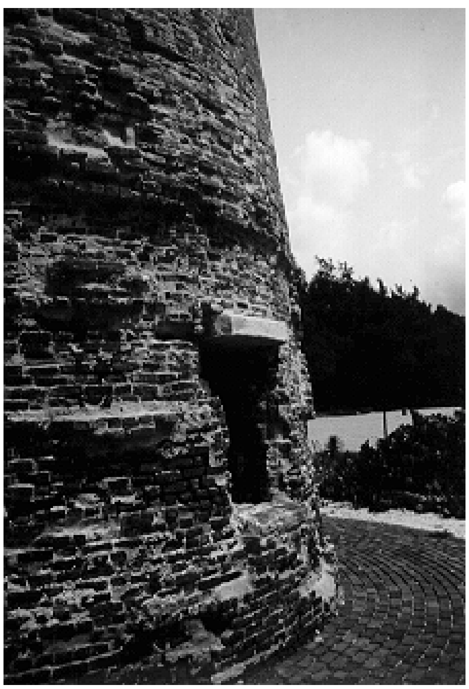

Figure 26. View of the lower tower window; note the depth of the brick deterioration at the window openings. The face of the protruding granite lintel above the window opening represents the face of the original wall.

A condition assessment performed in 1989 stated that the outer brick surface was severely deteriorated with large areas covering approximately 40% of the first brick wythe missing.[2] Two causes contributed to the deterioration of the lighthouse's exterior brick. First, there was the lack of maintenance for the circa-1870-applied mortar wash coating after deactivation of the lighthouse in 1878. Second, the remaining remnants of the exterior mortar wash coating were removed from the brick during the 1960s renovation by sandblasting. Sandblasting is a treatment method that pits the masonry surface, exposing the soft inner core of the bricks, thus accelerating weathering and deterioration. Despite this deterioration the condition assessment determined that the tower was constructed of good quality bricks, and the tower remained structurally sound.

In 1996, the Cape Florida Lighthouse was restored to its 1846 appearance. The severe deterioration of the exterior brick required the replacement of nearly 26,000 bricks. Before installing the replacement bricks, the exterior surface of the lighthouse was stabilized by removing the deteriorated mortar and repointing with a similar mortar mix that was used historically. The mortar used was designed to be compatible with the strength of the extant bricks. The areas of missing bricks were repaired using new replacement hand-molded bricks and masonry anchors. The masonry anchors were placed in holes drilled into the existing bricks and then set with mortar. This treatment helped to tie together the old and new masonry.

To protect the historic bricks from further deterioration, the exterior of the tower was coated with a sacrificial lime mortar wash. Protection of the soft masonry is vital to

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[2] Bert L. Bender, *Architectural and Engineering Report, Cape Florida Light, Key Biscayne, Dade County, Florida*, Key West, Florida, November 1989.

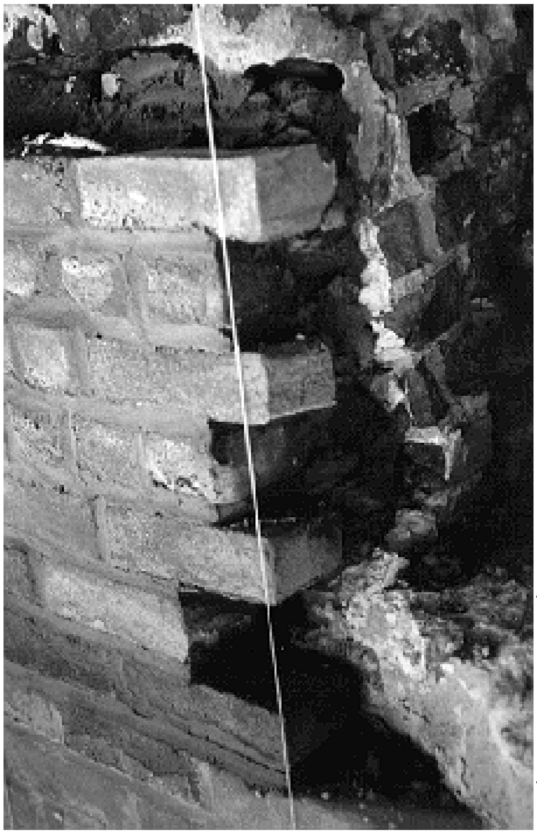

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Figure 27. View of repairs being made to the exterior wall. A new brick wythe is being installed where bricks were missing, using mortar that matches the strength of the new and historic bricks. Masonry anchors are used to attach the new wythe to existing wall. The deteriorated mortar joints in the extant wall were repointed with a matching mortar mix.

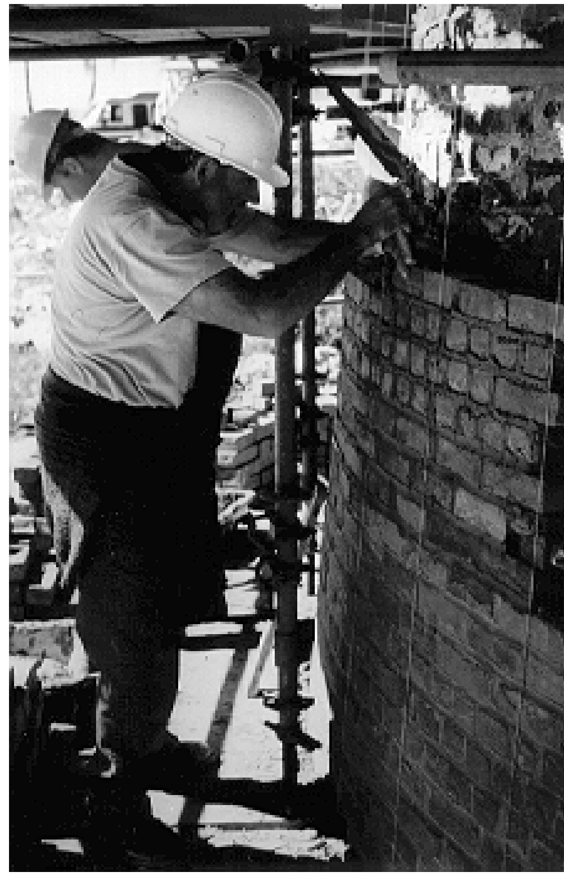

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Figure 28. Here a mason is implementing repairs to the exterior wall. The missing bricks were replaced with in-kind materials: the bricks match the historic bricks in size shape and strength. The mortar joint sizes are also being made to match the historic in size, color, and texture, as demonstrated in this photo. The vertical strings over the brickwork define the wall plane, so when the mason places the bricks, they maintain the taper of the conical tower.

maintaining the historic fabric and character of the structure. The sacrificial lime mortar wash is a three-coat system that was applied with natural bristle whitewash brushes. The specification for the lime mortar wash mix was as follows:

3-coat lime mortar wash:

1st - 6 parts lime, 6 parts sand, 1 part portland cement.

2nd - 12 parts lime, 6 parts sand, ½ part portland cement

3rd - 1 finish coat whitewash - water and lime mix (no sand)

This coating system allows the porous brick to ‘breathe’; therefore any moisture trapped in the brick can escape. Non-breathable coatings tend to trap moisture in the walls, which can accelerate the deterioration of the masonry. The life expectancy of this coating is approximately ten years in this part of the country.

SIDEBAR: The Building of Minots Ledge Light Station

For many people, their vision of a classic lighthouse is a wave-swept tower. John Smeaton, an Englishman, built the first successful wave-swept tower in 1759 at Eddystone Rock, in the English Channel, made famous by the song *Eddystone Light*. This was the first interlocking-masonry-block lighthouse tower. Later Smeaton developed a cement that would set up in water. These two inventions revolutionized open-sea lighthouse construction and remained the principal method for their construction until concrete and steel came into use just after the turn of the 19th century. Wave-swept towers were built by interlocking large cut stones, both horizontally and vertically. This integral inter-tonguing formed a monolith of great weight, which combined with their conical shape, diverted the energy of the waves away from the tower, enabling them to withstand the heavy pounding of the surf.

Minots Ledge Lighthouse, located on a rock barely visible above the sea near the entrance to Boston Harbor, Massachusetts, is America's

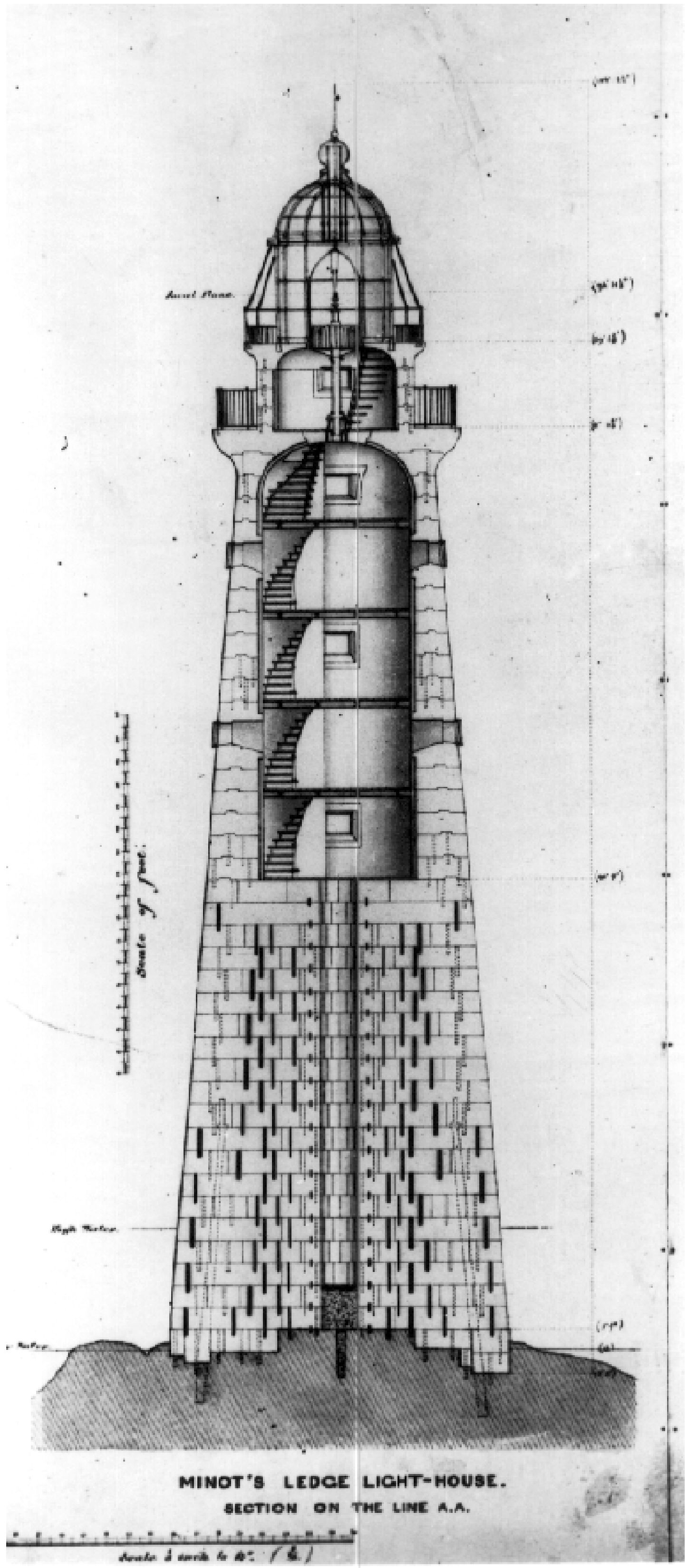

Figure 29. Cross section for 114-foot Minots Ledge Lighthouse.

National Archives photo

version of Eddystone Lighthouse. The first wave-swept stone tower to be built in the United States, it took five years to complete and cost approximately $300,000 to build. Between 1832 and 1841 over 40 vessels had been lost in the area of Minots Ledge. In 1847 Congress appropriated $20,000 for construction of the first Minots "Rock" Lighthouse—the first iron straight-pile lighthouse built in the United States. The lighthouse consisted of a skeletal wrought-iron pile tower built with one central and eight periphery wrought-iron piles, wedged into holes drilled in the ledge—designed to provoke the least amount of resistance to the sea. Construction equipment was twice swept from the rock during summer storms; workmen were several times swept into the sea by unexpected waves, but none were drowned. The first Minots Ledge Lighthouse, lit on January 1, 1850, was destroyed in a storm on April 16, 1851; both keepers were lost. The piles were found twisted and broken, leaving stubs still wedged in place.

On August 31, 1852, Congress approved the erection of the second and still standing lighthouse on the "Outer Minots rock." This time the design chosen was one of interlocking granite blocks. The plans consisted of a masonry tower in the form of a frustum of a cone, solid for the lower 40 feet of its 114-foot height. Because the ledge was exposed only at low tide and on calm days, the work was very slow. Tides were found to be right only "six times during any one lunation, three at full moon and three at the change." It took three years to prepare the ledge for the first course of granite masonry which was cut and test assembled on nearby Gulf (later called Government) Island, near Cohasset, where the government acquired 7.3 acres of farmland for a staging area for the building of the second lighthouse. Here stone-sheds were erected for the stone cutters and a perfectly flat pavement prepared so the stones once cut could be pre-assembled for correct fitness. Granite from Quincy was chosen as being "finest of grain, toughest and clearest of sap." An iron scaffold was erected on the ledge for the safety of the

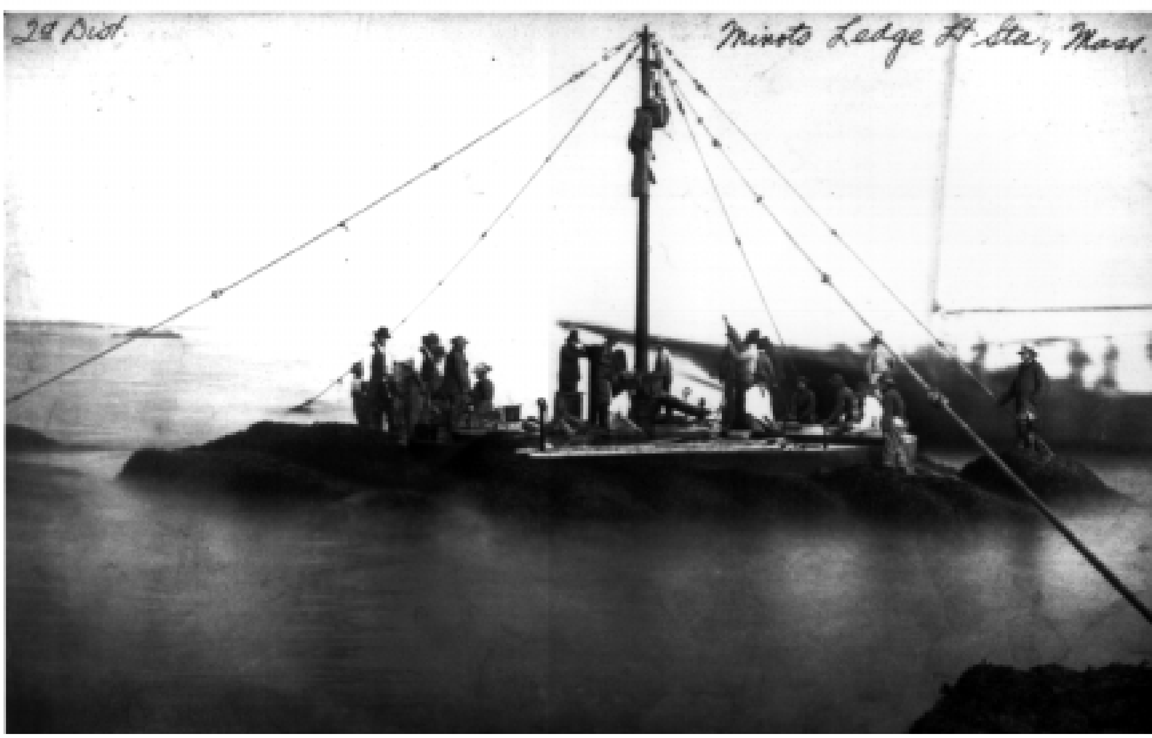

Figure 30. Workers on a calm day, completing the first course of granite block for the foundation of Minots Ledge Lighthouse, 1858

workmen and to facilitate the tedious and difficult operations on the rock. Captain Michael "Neptune" Brennock was hired as lifeguard. He stationed himself in a sloop along side the rock to pick up workmen whom the waves swept from the ledge. Additionally a man was posted to warn the workmen of incoming large waves, hollering out "roller coming!" when necessary.

National Archives photo

Figure 31. Work on Minots Ledge Lighthouse as it progressed just above the entrance level which is visible on the left. The tower below this level was essentially solid.

Permanent iron shafts, about 20 feet high were set in eight of the holes in which the old lighthouse piles had been placed, while the central hole was left open to form a cavity for the base circle of stones—later formed into a 2,200 gallon capacity cistern. Ropes attached to the piles were used by the workman to grasp when waves washed over the ledge. The piles were also used as derricks in laying the stones. This framework was destroyed on January 19, 1857, when the bark *New Empire* struck the ledge during a severe storm and altered the rock surface, necessitating a change in the shape of the foundation stones. New pilings were inserted in the holes, this time 25 feet long. Temporary cofferdams were constructed from sand bags so the foundation stones, which lay more than two feet below low tide, could be cemented to the rock ledge. After much experimentation, it was determined that the mortar should be spread on muslin cloth and wrapped around each stone before it was lowered into place. The mortar was then compressed by the weight of the stone and oozed through the cloth and formed a good adhesion with the rock-surface. Each stone was "dovetailed and doweled to each other in the securest manner" so that the pressure from the impact of the waves tightened instead of weakening the union. Each foundation stone weighted about two tons and was fastened to the rock by 2-inch galvanized wrought-iron bolts. Strap irons attached between the piles kept the stone courses apart until the cement hardened.

The lighthouse was ceremoniously lit August 22, 1860, one day short of five years after beginning construction. But the light was not regularly shown until November 15 when the keepers assumed their official duties. Unlike the first pile structure, the stone wave-swept tower has survived to the present. Minots Ledge Lighthouse is considered the "most important engineering work" constructed by the U.S. Lighthouse Board; "it ranks, by the engineering difficulties surrounding its erection, and by the skill and science shown in the details of its construction, among the chief of the great sea-rock light-houses of the world."

Historic Lighthouse Preservation:

IRON

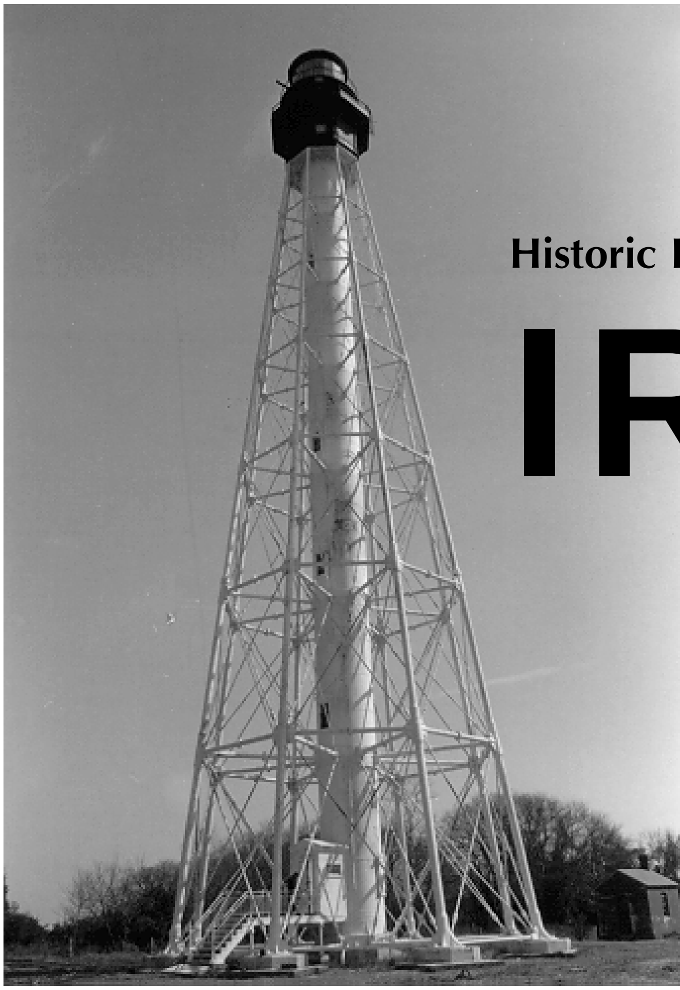

Figure 1. Cast-iron-and-steel skeletal 191-foot-tall tower at Cape Charles, Virginia

Second to masonry, iron was the most common lighthouse construction material. For lighthouse construction, iron was used in a variety of its commercially manufactured alloys: wrought iron, cast iron, steel, galvanized iron and steel, and stainless steel. In historic lighthouses the most widely used alloy was cast iron. The use of cast iron in lighthouse construction ranged from simple prefabricated lanterns to caisson-style foundations to 190-foot-tall first-order coastal towers. For more on the variety of iron lighthouse construction types refer to Part II., **History of the Lighthouse Service and Lighthouse Construction Types**.

Iron was also used for the production of architectural trim features such as gallery deck brackets, entryway pilasters and pediments, doors, and prefabricated lantern components. These iron features were used on masonry and wood as well as iron lighthouses. Other iron alloys such as steel, galvanized iron and steel, and stainless steel are mostly found in modern additions such as handrails, equipment brackets, security doors, etc.

This section will discuss the preservation of iron alloys used in lighthouse tower construction and decoration. Because of their similar properties, the various iron alloys will be discussed together; special treatments concerning a specific alloy will

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Figure 2. Example of a keeper's quarters fitted with a prefabricated cast-iron-and-steel lantern.

WPTC photo

Figure 3. Example of an all-cast-iron construction "sparkplug" caisson-style lighthouse.

WPTC photo

Figure 4. Double-wall, cast-iron, first-order 163-foot-tall coastal tower at Cape Henry, Virginia.

be discussed accordingly. The use of iron in the construction of lanterns and the special considerations associated with iron in the presence of unlike metal corrosion (galvanic corrosion) will be discussed in the **Lantern** section. Other metals such as brass and bronze will also be discussed in the **Lantern** section.

Iron Alloys Found in Historic Lighthouses

Of the iron alloys, cast iron was a perfect choice for lighthouse construction for two principal reasons. First, cast iron is relatively resistant to corrosion because of its microstructure component compounds—graphite and phosphide eutectic. These compounds are not present in steel, which explains why the two materials corrode in different manners. Second, cast iron can be cast into virtually any shape that is required for structural or decorative purposes. To form complex shapes and structural systems, these castings were designed with flanges that made it possible to bolt the component parts together. This prefabricated style of construction facilitated the erection of lighthouses in a timely, economical manner. This method also allowed for the dismantling and relocation of a lighthouse if site conditions were compromised by encroaching erosion.

The various steel alloys were used throughout the structure of a historic lighthouse, but to a lesser degree than cast iron. Most mild steel, stainless steel, and galvanized steel components have been used in modern additions or repairs. These components appear mostly as pre-

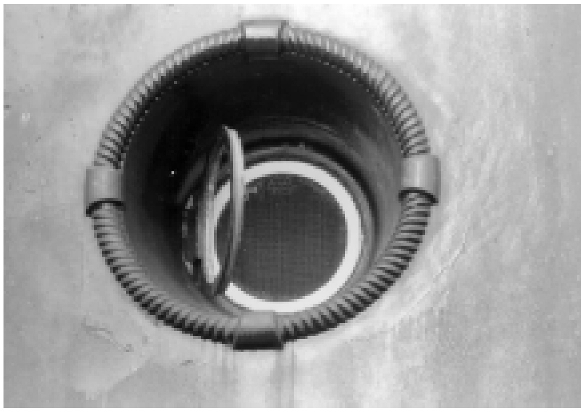

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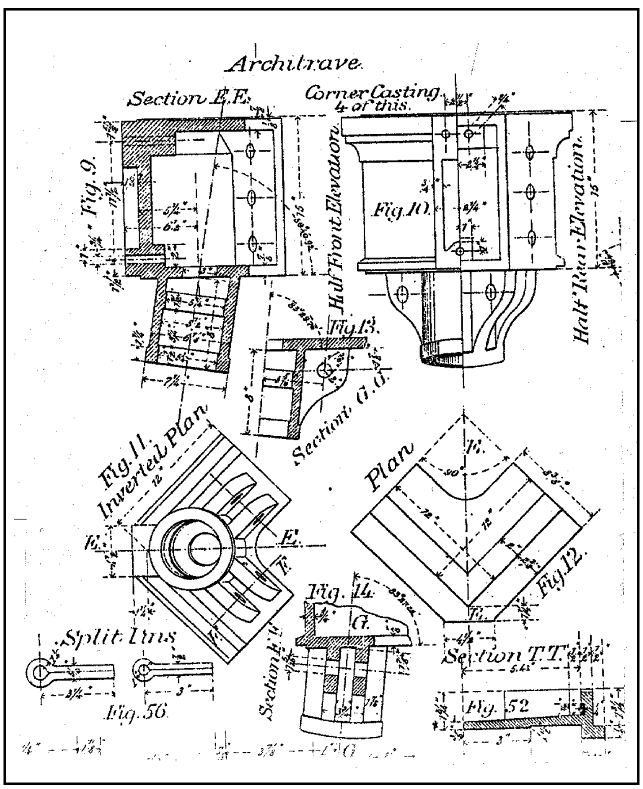
Figure 5. A view of decorative-rope nautical-style cast-iron window surrounds on Cape Canaveral Lighthouse.

manufactured items such as structural ‘I’ beams, replacement handrails, equipment brackets, and items that can be fabricated into functional parts of the lighthouse.

WPTC photo

Figure 6. A view of the inner cavity and skeletal structure of the Cape Henry Lighthouse.



National Archives

Figure 7. Shop drawings used for the production of cast-iron lighthouse parts for a screwpile lighthouse.

Iron Alloys Commonly Found in Historic Lighthouses

- ***Wrought iron*** is relatively soft, malleable, tough, fatigue-resistant, and easily worked by forging, bending, rolling, and drawing. Until steel was available, wrought iron was used structurally for beams and girders as it had strength in both tension and compression. During the late 19th and early 20th centuries, it was not unusual to find a mixture of cast-iron columns and wrought iron or steel beams in the same lighthouse. Currently, very little wrought iron is being produced.
- ***Cast iron*** is an iron-carbon alloy with a high carbon content. It is easily poured while molten into molds, making possible numerous decorative and structural uses. Cast iron is too hard and brittle, however, to be shaped by hammering, rolling, or pressing. Cast iron contains in its microstructure several relatively corrosion resistant components which are mostly absent from the microstructure of steel. Because of this, the two materials corrode in different manners. It is more rigid (highly resistant to buckling) than other forms of iron and can withstand

great compressive loads, which helps account for its ubiquitous use for lighthouse tower structure components such as wall plates, columns, sockets, struts, deck plates, etc. Cast iron does have some drawbacks. There is the potential for inherent flaws in cast pieces such as trapped air pockets or foreign material such as casting sand or slag trapped in the iron during the casting process. These flaws can be avoided if the castings are thoroughly inspected and the casting process is performed to accepted industry tolerances.

- ***Steel*** is an alloy of iron and carbon that contains not more than 2% carbon, and is malleable in block or ingot form. Steel may include phosphorus, sulfur, oxygen, manganese, silicon, aluminum, copper, titanium, molybendum, and nickel. The properties of steel can vary greatly in relation to the chemical composition and the type of heat treatment and mechanical working used during manufacture. Characteristics affected by these differences include strength, hardness, ductility, resistance to abrasion, weldability, machinability, and resistance to corrosion. A grade of medium carbon steel is used for most lighthouse applications today such as handrails, equipment brackets, new light support structures, etc.
- ***Galvanized steel*** and ***iron*** consist of steel or iron with a zinc coating, which makes it highly resistant to corrosion. As in the past, zinc is still widely used as a protective coating for iron and steel. A major advantage of zinc coating on iron is that if the zinc is worn away or broken and the iron is exposed to the atmosphere, galvanic corrosion of the more base zinc occurs, protecting the more noble iron. (The terms *base* and *noble* refer to the relative reactivity of the zinc and iron. A metal that is considered a *base* is more reactive than a metal that is considered *noble.* These properties are directly related to the number of free electrons that exist in the molecular structure of the metal.)
- ***Stainless steel*** is defined as a steel containing sufficient chromium, or chromium and nickel, to render it highly resistant to corrosion. Stainless steel is malleable, hardened by cold working, and resistant to oxidation, corrosion, and heat. It has characteristics of high thermal expansion and low heat conductivity, and can be forged, soldered, brazed, and welded. Because of its relatively inert properties, stainless steel components are mostly found in replacement parts such as bolts where the possibility of galvanic corrosion could occur.

Stainless steel is available in various grades. Given the complexity of the issues and potential application, the selection of the proper grade of stainless steel for use in a marine environment requires careful evaluation by an engineer.

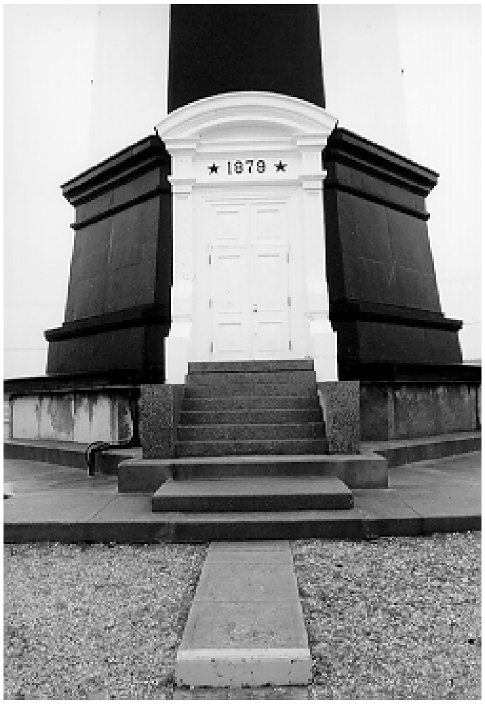


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Figure 8. An example of the level of detail achieved with cast-iron construction.


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Figure 9. A modern range finder attached to the gallery deck using modern steel members.

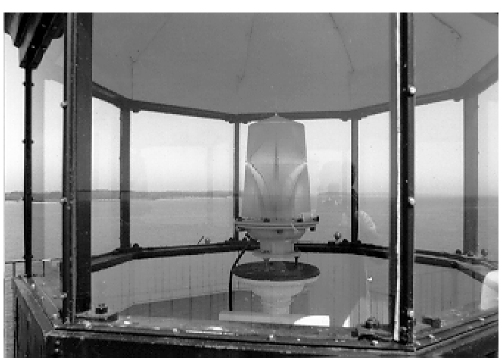
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Figure 10. Close-up of a lantern glass frame: note the use of stainless steel bolts; the lower clamps are also stainless steel that have been painted black.

Figure 11. Detail view of a steel ladder that has been uniformly attacked by corrosion.

Causes of Iron Deterioration and Failure

Iron lighthouse components are subjected to a host of forces associated with a marine environment. How successfully a lighthouse resists these pressures depends on how well it is designed and maintained. Iron lighthouses that are poorly maintained will deteriorate rapidly.

In scientific terms, *deterioration* is generally defined as a decrease in the ability of the material to fulfill the function for which it was intended. It usually refers to the breakdown of a material because of natural causes, although deterioration can also be either directly or indirectly caused by man. Deterioration can also be defined as the changing of a material from a higher to a lower energy state. Although deterioration usually implies a chemical change, under some conditions the change can be physical. There are five possible forces that can act on an iron lighthouse component and cause its failure: corrosion, inherent flaws, mechanical breakdown, weathering, and connection failure.

Corrosion

Corrosion, in one form or another, is the major cause of the deterioration of iron lighthouse components. Often called oxidation, it is the chemical reaction of a metal with oxygen or other substances. The deterioration of iron lighthouse components is a complex process because the type and degree of corrosion is affected by minor variations in environment, contact with other metals and materials, and the composition of the component itself.

Upon exposure to the atmosphere, almost all new or newly cleaned metals become coated with a thin film of metallic oxide, which is a result of the reaction of the metal with oxygen. This film may modify the properties of the metal and make it less susceptible to further corrosion. In the case of rusting iron, however, the oxide does not form a protective coating but rather promotes the continued corrosion of the metal. The three most common types of corrosion experienced by iron lighthouse components are as follows:

- ***Oxidation*** or rusting occurs rapidly when the iron component is exposed to moisture and air. The minimum relative humidity necessary to promote rusting is 65%, but this figure can be lower in the presence of corrosive agents, such as sea water, salt air, acids, acid precipitation, soils, and some sulfur compounds present in the atmosphere, which act as catalysts in the oxidation process. Rusting is accelerated in situations where the shape of the iron details provide pockets or crevices to trap and hold liquid corrosive agents. Furthermore, once a rust film forms, its porous surface acts as a reservoir for liquids, which in turn causes further corrosion. If this process is not arrested, it will continue until the iron is entirely consumed by corrosion, leaving nothing but rust.
- ***Galvanic corrosion*** is an electrochemical action that results when two dissimilar metals react together in the presence of an electrolyte, such as water containing salts or hydrogen ions. The

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Figure 12. Close-up of localized corrosion or pitting where the corrosion has eaten through the cast iron.

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Figure 13. View of a steel railing where corrosion has occurred in distinct locations either because of variations in composition or localized failure of the coating system.

severity of the galvanic corrosion depends on the difference in potential between the two metals, their relative surface areas, and span of time. If the more noble metal (higher position in electrochemical series) is much larger in area than the baser, or less noble, metal, the deterioration of the baser metal will be more rapid and severe. If the more noble metal is much smaller in area than the baser metal, the deterioration of the baser metal will be much less significant. Iron lighthouse components will be attacked and corroded when they are adjacent to more noble metals such as lead or copper. For more on *galvanic corrosion* refer to the **Lantern**.

- ***Graphitization*** of cast iron, a less common problem, occurs in the presence of acid precipitation or seawater. As the iron corrodes, the porous graphite (soft carbon) corrosion residue is impregnated with insoluble corrosion products. As a result, the cast-iron element retains its appearance and shape but is weaker structurally. Graphitization occurs where cast iron is left unpainted for long periods or where caulked joints have failed and acidic rainwater has corroded pieces from the backside. Testing and identification of graphitization is accomplished by scraping through the surface with a knife to reveal the crumbling of the iron beneath. Where extensive graphitization occurs, usually the only solution is replacement of the damaged element.

Inherent Flaws

Castings may also be fractured or flawed as a result of imperfections in the original manufacturing process, such as air holes, cracks, and cinders, or cold shuts (caused by the “freezing” of the surface of the molten iron during casting because of improper or interrupted pouring). Brittleness is another problem occasionally found in old cast-iron elements. It may be a result of excessive phosphorus in the iron, or of chilling during the casting process.

The corrosion of iron lighthouse components takes several forms:

- ***Uniform attack*** is where the iron component corrodes evenly where exposed to corrosive agents.
- ***Pitting*** is the localized corrosive attack on the iron component.
- ***Selective Attack*** can occur where an iron component’s composition is not homogeneous and certain areas are attacked more than others.

- ***Stress corrosion cracking*** can occur where stresses were induced into the iron component in the pulling or bending process of metalworking and the component later subjected to a corrosive environment. For example, stainless steels can crack in environments containing chloride, and carbon steels in nitrate, cyanide, or strong caustic solutions.
- ***Erosion*** occurs when the corrosion-resistant film or oxide or layer of protective corrosion product is removed by abrasion, exposing fresh metal to the corrosive agents.

Mechanical Breakdown

Iron lighthouse components can also fail from purely physical causes such as abrasion, or a combination of physical and chemical attack, such as weathering and stress corrosion cracking.

- ***Abrasion*** is the erosion of the iron component caused by moving dirt, dust, sand, grit, sleet, and hail, or rubbing by another lighthouse component or human element. Abrasives can also encourage corrosion by removing the protective coating (paint) from the iron lighthouse component.
- ***Fatigue*** is failure of an iron component by the repeated application of cyclic stresses below the elastic limit—the greatest stress a material can withstand without permanent deformation after removal of the load. It results from a gradual or progressive fracture of the crystals.


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Figure 14. Nearly 30% of this ventilation shroud has been lost to two forms of abrasion: first, sand or grit blasting abraded away a majority of the material; second, human touch has smoothed the once rough surface.


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Figure 15. As corrosion attacked this steel handrail, wind and airborne sand eroded the loose and flaking surface rust.

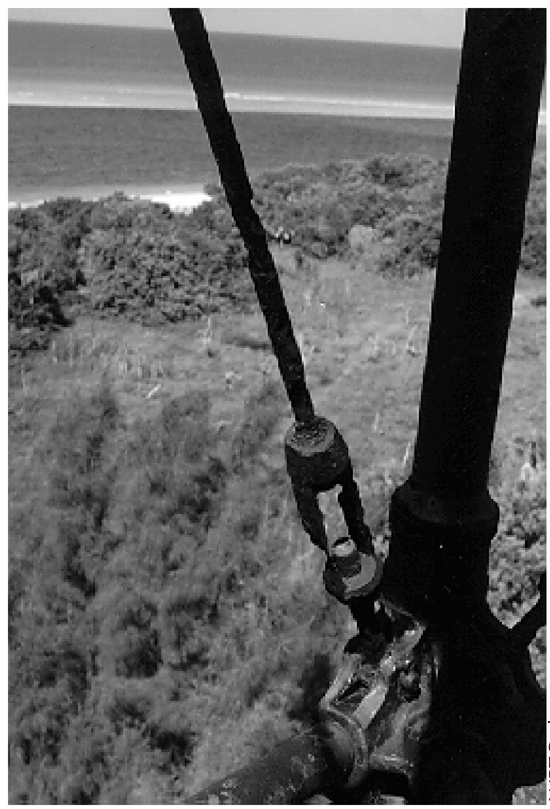
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Figure 16. As corrosion attacked this steel turnbuckle, wind and airborne sand eroded away the flaking rust.

- ***Overloading*** is the stressing of an iron lighthouse component beyond its yield point so that permanent deformation, fracturing, or failure occurs. It can fail through the application of static loads, dynamic loads, thermal stresses, and settlement stresses either singly or in combination. “Buckling” is a form of permanent deformation from overloading which is usually caused by excessive weight but can also be caused by thermal stresses. Members can also be overloaded if their support is removed and loads are redistributed to other members which can become overstressed and deformed. An iron lighthouse component can fail or become permanently deformed by the phenomenon known as rust-jacking. The failure or deformation is the result of the expansion of the iron component as it oxidizes. This expansion “jacks” the two members apart.

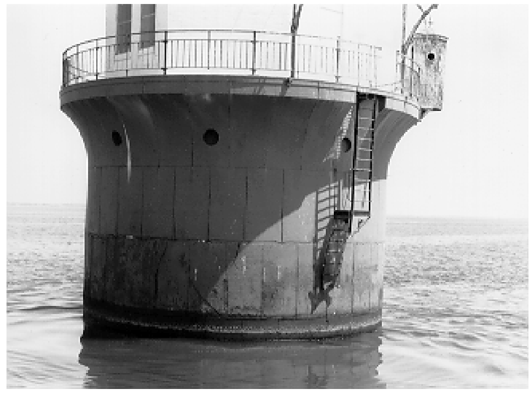

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Figure 17. The cyclic pressure of the different rates of expansion and contraction of the exterior cast-iron plates and the interior brick lining of the caisson-style lighthouse has caused the cast-iron plates to fatigue and crack.

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Figure 18. The internal structural skeleton of this lighthouse is cracked because of overloading possibly during assembly.

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Figure 19. This handrail has been damaged by rust-jacking; rusting began between the two pieces of flat bar stock that formed the rail.

Weathering

An iron lighthouse component subjected to the weather is exposed to various chemical and physical agents singly and in combinations of several at one time. The result is a kind of synergism where the total effect is greater than the sum of the individual effects taken separately. For example, the rate of corrosion accelerates with increases of temperature, humidity, and surface deposits of salts, dirt, and pollution.

Connection Failure

The failure of the connections of iron lighthouse components, especially structural members, can also be caused by a combination of physical and/or chemical agents. The most common type of connections used for iron structural elements of historic lighthouses include bolting, riveting, pinning, and welding. These connections can fail through the overloading, fatiguing, or corrosion of the connectors. Common examples of this type of failure include the corrosion, usually by concentration cells (or battery affect caused by dissimilar metals), of bolt heads, rivets, and areas covered by fastening plates. The effective cross-sectional area of the connectors is often reduced by corrosion, making the connectors more susceptible to stress failure.

Inspecting for Possible Problems

In order to develop an effective treatment plan for iron lighthouse problems, an in-depth inspection must be made of the iron lighthouse and its immediate surroundings. The following chart is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Iron Lighthouses	
THE SITE	
Look For:	*Possible Problems:*
Environment	
General climatic conditions, including average temperatures, wind speeds and directions, humidity levels, and average snow accumulation	Severe conditions can lead to deterioration of the masonry foundation, which in turn could lead to differential settlement that could ultimately damage the iron lighthouse structure.
Number of freeze-thaw cycles	Severe cycles can cause damage to iron lighthouse components from frost action.
Location near sea	Salt (chloride) in the air can lead to accelerated corrosion of exposed iron surfaces.
Acid rain in the region or from nearby industry	Acid rain can lead to accelerated corrosion of exposed iron lighthouse components.
Proximity to a major road highway or railroad	Vibrations are harmful to masonry foundation mortar joints as well as iron lighthouse parts. Repetitive vibration can cause premature failure in iron components if the oscillation cycles fatigue the metal to the point of failure.
Location in the flood plain of a river, lake, or sea	Floodwaters can bring damaging moisture to foundations and walls; such damage can result in differential settlement that could ultimately damage the iron lighthouse structure.
Exposed or sheltered sections of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration into the joints between iron members. Sheltered areas such as the underside of an iron gallery deck are highly susceptible to corrosion and rust pitting because of a tendency to accumulate moisture and the slow drying rate without direct sunlight.
Terrain	
Soil type—clay, sand, rock	The type of soil influences water drainage around the structure. Excessive water in the soil could lead to differential settlement that could ultimately damage the iron structure. This is a minimal concern for most iron lighthouses. Most iron lighthouses were constructed on sites that had been chosen for their soil and/or underlying strata stability.

Look For:	*Possible Problems:*
Slope away from lighthouse on all sides	If no slope exists, puddles will form at the base of the lighthouse walls during heavy rains, causing water penetration and possible damage to foundation systems that could lead to differential settlement and ultimately to damage of the iron structure.
Earth covering part of a brick or stone wall or foundation	Moisture accumulation or penetration is possible and could lead to differential settlement and ultimately to damage of the iron structure.
Concrete or other impervious paving touching walls	Water accumulation and rain back-splash onto the walls which could lead to accelerated corrosion of the iron wall structure.
Trees and Vegetation	
Species of trees within 50 feet	Elms and some poplars dry up clay soil, leading to foundation failure and differential settlement that could ultimately damage the iron lighthouse structure.
Branches rubbing against a wall	Branches abrade surfaces, possibly exposing bare iron surfaces to the elements and accelerating corrosion of the iron lighthouse structure.
Ivy or creepers on walls	Leaves prevent proper drying of the painted iron surface resulting in possible accelerated corrosion of the iron surface. Tendrils from some species can penetrate joints and can literally break the iron lighthouse members.
THE LIGHTHOUSE	
Overall Condition	
General state of maintenance and repair	A well maintained lighthouse should require fewer major repairs.
Evidence of previous fire or flooding	Such damage may have weakened the lighthouse structural members or caused the introduction of excessive moisture.
Signs of settlement	Uneven settlement can crack foundations and lead to differential settlement that could ultimately damage the iron lighthouse.

Look For:	*Possible Problems:*
Lantern	
General condition	A well maintained lantern should require fewer major repairs. A leaking lantern may leave stains under the gallery deck on the exterior of the lighthouse as well as streaks on the interior walls of the tower spaces below. This condition can introduce excessive moisture into the interior of the lighthouse and possibly cause accelerated deterioration of interior features and structure.
Roof drains (usually associated with larger first-order lights) and covering	Clogged roof drains can hold water in the built-in guttering system and accelerate deterioration of the roof covering. Small holes in the roof covering can be moisture infiltration points.
Gallery decks, copings, and structural seams	Gaps in gallery decking can allow water to penetrate in the interior cavities of an iron tower wall.
Condition of storm panels	Cracks and holes in storm panel glazing can provide an infiltration point for moisture into the lantern.
Humidity level within the lantern	Non-functioning lantern vents can inhibit the release of humid air from within the tower. The water vapor will ultimately condense on the surfaces inside the tower and lantern and possibly cause accelerated corrosion of iron lantern components.
Windows and Doors	
Straight and square openings	Deformed openings in the lighthouse structure may be a sign of structure settlement.
Door and window sills sloped to shed water; drips under sills to prevent water from running back underneath; caulking	If any of these is inadequate, water can penetrate into the wall and start corrosion from the inside out.
Foundation	
Composition of foundation walls	Stone or brick is more likely than concrete to allow water to infiltrate.
Water condensation or other signs of moisture	Wood joists or iron structural members resting on masonry foundation walls may begin to rot or corrode at the ends. Termites or algae, mold, mildew, or moss may be present, causing damage to the wood or masonry.
Damp proof course	This can impede rising damp, lessening deterioration of the masonry wall.

Look for:	*Possible Problems:*
Interior	
Damp walls, stains on walls, rotting wood	These indicate water infiltration.
Walls	
Construction method—iron plate, sheet iron double wall, iron plate with masonry infill, wood frame interior walls, etc.	Knowing how a tower wall is constructed will help in analyzing problems and selecting appropriate treatments.
Masonry-lined iron lighthouses	Rust-jacking of iron members captured by masonry infill may cause cracking of the infill. If the masonry infill becomes wet, the different rates of expansion and contraction of the masonry infill and the iron sheathing during a freeze-thaw cycle can cause the iron and masonry both to crack.
Sheet iron cavity walls	Water infiltration will show as rust forms on the interior of the cavity and appears as blistering on the exterior of the panels. Rust streaks known as 'rust weep' or 'rust bleed' appearing on interior wall surface plate seams may indicate water infiltration has occurred.
Iron Components	
Materials	
Type of iron—wrought, cast, steel, galvanized steel, or stainless steel	Types of materials indicate the susceptibility or resistance to damage and proper repair method.
Areas of intricate castings or moldings	These sections may need special attention or protection during treatment.
Missing or broken iron components	Missing material may allow water penetration.
Evidence of sandblasting, such as a pitted surface; evidence of erosion, flaking, scaling, or other form of corrosion.	Surface deterioration is not only aesthetically displeasing but can lead ultimately to the complete deterioration of the lighthouse.
Dirt or stains	Surface stains usually cause few problems other than being unpleasant to look at. Accumulated dirt or debris in built-in gutters or other 'pockets', however, may trap water and cause accelerated corrosion.
Moisture	
Water penetration through joints between iron components and between iron and other lighthouse components	Moisture can lead to deterioration of the iron and other parts of the lighthouse structure through corrosion and rot. Water that has entered a cavity may go unnoticed until extensive corrosion has occurred.

Look for:	*Possible Problems:*
Location and type of corrosion on surface	The type of corrosion may indicate the source of the deterioration; refer to the following section on corrosion for more information.
Rust streaking or 'rust weep' present on interior or exterior wall surfaces near seams or construction joints in the iron structure	This condition indicates that moisture has penetrated the joint or interior cavity of the iron wall. The water entry point should be identified and sealed or the damaged area repaired.
Coatings	
Paint; type of paint	Various paint types require different treatment methods and safety precautions, i.e., lead-based paint hazards, etc.
Blistering, flaking, and peeling paint	These conditions indicate the paint is at or near the end of its effective life span.
Rust streaks or rust weep	This indicates localized failure of the coating system which has caused the exposed iron to begin to rust. The rust scale should be removed and the area spot painted in the interim until the next repainting of the lighthouse.
Construction Joints	
Joints between iron lighthouse components were typically sealed with white lead mixed with linseed oil	The white lead/linseed oil mixture hardens and becomes brittle over time and eventually falls out, thus allowing open joints for water infiltration.
Concrete or mortar used as a seam or cavity filler	The concrete and mortar are very hard and can easily break and thus allow for water infiltration; cavities in an iron lighthouse that have been filled with concrete or mortar are susceptible to corrosion because of the alkalis present in the concrete and mortar and the possible trapping of water between the filler and the iron.
Iron copings over masonry portions of the lighthouse such as watertables and window and door surrounds.	The alkali nature of the mortar used in the masonry may cause the iron to prematurely rust. These areas are prone to rust weep and should be thoroughly cleaned of rust scale and painted during the scheduled lighthouse repainting.

PRESERVATION TREATMENTS

WARNING: Many of the maintenance and repair techniques described in this text, particularly those relating to cleaning and painting, are potentially dangerous and should be carried out only by experienced and qualified workmen using protective equipment suitable to the task. It may be necessary to involve a USCG engineer or architect, preservation architect, or building conservator familiar with lighthouse preservation to assess the condition of the iron and prepare contract documents for its treatment.

Cast-iron and steel features such as gallery deck brackets, handrails, skeletal structures, pilasters and door pediments, window architraves, as well as textured, finished surfaces such as raised diamond pattern non-skid surfaces, are important in defining the historic character of the lighthouse (see Figures 20 and 21). It is essential that the character-defining features are retained during any treatment. It should also be noted that while cast iron is among the most durable of historic building materials, it is also the most susceptible to damage by improper maintenance or repair techniques and by harsh or abrasive cleaning methods. Therefore, all treatment should be executed using the gentlest means possible. In Part V., **Beyond Basic Preservation**, examples of treatments that are considered rehabilitation and restoration are illustrated and discussed.


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Figure 20.


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Figure 21.

Protection and Stabilization (Mothballing)

Despite their inherent durability, a historic iron lighthouse that receives only minimal or no routine maintenance is highly vulnerable to decay if it is not protected and stabilized properly. To properly protect and stabilize a historic iron lighthouse, a thorough inspection and diagnosis of all iron features: caisson structures, cast-iron plate walls, decorative features (cornices, door and window surrounds, decks, etc.) should be performed using the inspection chart in the preceding section as a guide. The results of the inspection are then used to develop a protection and stabilization plan. The following recommended protection and stabilization guidelines for vacant historic iron lighthouses are the minimum treatment requirements to prevent any further damage from occurring.

Weatherization

It is essential that all iron components be completely weathertight. Water intrusion can be extremely detrimental to iron components. If water enters the interior cavity of an iron component it will cause corrosion to occur, or accumulated water can freeze and the resulting expansion can possibly crack the component.

To prevent moisture penetration be sure the following infiltration points are weathertight or functioning properly:

- ***Lantern system:*** Cast-plate or sheet-iron lantern parapet walls, all lantern glass, cast-iron frames, and roofs must be weathertight. Caulk patches should be used only as a temporary fix and not relied on as a long-term treatment as they have a limited functional life span. Refer to the **Lantern** section of this handbook for more information concerning the weatherproofing of the lantern components.
- ***Built-in guttering systems:*** In order to prevent water from entering the interior cavity of double-wall iron or brick-lined iron wall systems, all rain water guttering systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. It is imperative that all holes and non-functioning gutter system components are repaired. For more information refer to the discussion on roofing in the **Lantern** section of the handbook.
- ***Gallery decks:*** The seams between cast-iron gallery deck plates must be made weathertight. If rust is already present, this must be removed and the affected areas primed and painted. The joints should be sealed with a high quality

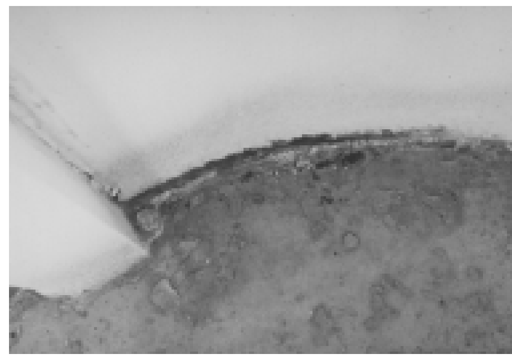

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Figure 22. Interior of a sheet-iron parapet wall that is rusting from the inside to out along the lantern room door. This is the result of water entering the interior cavity of the parapet wall.

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Figures 23 and 24. Two types of gutters found on iron lighthouses; the gutters must be in proper working order and checked regularly during the mothballing period.

Figure 25. The seams between the deck and wall plates of this lighthouse were not properly sealed; as a result the areas collected water and began to rust.

Figure 26. This steel casement window frame was not sealed properly and as a result has begun rusting from the inside out.

sealant. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior cavity of the tower wall and cause damage that may go undetected until severe deterioration has occurred. See the **Windows** section of this handbook for the proper caulk for this application. Refer to the **Lantern** section of this handbook for more information concerning the weatherproofing of gallery decks.

- ***Wall plates:*** The joints between cast-iron wall plates must be kept weathertight. If rust is already present, this must be removed and the affected areas primed and painted. The joints should be sealed with a high-quality sealant. If the wall plates are not weathertight, moisture can enter the interior cavity of the tower wall and cause damage that may go undetected.

- ***Door and window frames and trim:*** The joints along the perimeter of iron door and window trim and frames where the trim or frame is attached to a masonry or iron tower must be made weathertight. Open joints should be cleaned of rust and loose paint. The affected areas must be primed and painted, then sealed with a high-quality caulking. This will prevent water from entering the interior cavity of either the iron trim or the wall itself. See the **Windows** section of this handbook for the proper caulk for this application.

- ***Protective coatings:*** As a protective measure and for recognition as a daymark, lighthouses were historically painted. As part of a mothballing treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and spot-painted to match the existing color.

Ultimately, as part of a mothballing treatment, the entire lighthouse should have all loose paint and corrosion removed and a new coating applied to the entire surface according to the manufacturer's specifications. This action will result in a coating system that will require minimal service during the mothballed period. For more information refer to the paint and coating systems discussion under the repair treatment later in this section.

Figure 27. Blistering paint, as pictured here, should be removed and the affected areas properly primed and painted.

Stabilization

When mothballing an iron lighthouse or a lighthouse with iron components, all possible structural repairs should be made before the beginning of the "mothballed" period. If repairs cannot be made because of budget constraints, stabilization of the primary structural components should be first priority, followed by more general stabilization of the rest of the lighthouse. Temporary bracing and "splinting" may be possible techniques for non-structural components. More elaborate shoring may be required to support structural members that have failed or are in danger of failing. For situations where sophisticated structural bracing is required, a structural engineer or historical architect should be consulted for a proper stabilization treatment plan. The stabilization treatment utilized should not permanently damage historic character-defining features and should be easily reversible so that when the budget allows, the structure can be properly repaired. For more information refer to the discussion on structural stabilization under the repair treatment in this section.

Ventilation

Iron lighthouse towers are typically one of four possible construction types: single-wall cast-iron plate, double-wall cast-iron plate, brick-lined cast-iron plate, cast-iron-and-steel skeletal. With any of these construction types, adequate ventilation in the unoccupied lighthouse is essential during the mothballing period. Adequate ventilation will achieve two goals: 1) minimize excessive heat buildup which can damage any sensitive electronic equipment operating inside the tower; 2) minimize condensation buildup inside the lighthouse (especially brick-lined towers) that can cause the iron to corrode on the interior of the tower. In some extreme cases minimal heating may be needed to minimize moisture buildup in the lighthouse. Ventilation of iron towers through passive and mechanical systems is covered in the **Windows** section.

Fire Protection

Despite the fact that iron is noncombustible, fire is still a threat to combustible components of iron lighthouses and can possibly cause permanent deformation to the iron components exposed to intense heat. For guidance on these issues, refer to "Fire Prevention and Protection Objectives under **Related Activities** in Part VI.

Repair

Before any preservation repair work is begun, all iron features that are important in defining the overall historical character of the lighthouse, such as walls, brackets, cornices, window architraves, door pediments, steps and pilasters, coatings and color should be identified. During all repair work it is imperative that measures are taken to ensure that these features are not damaged or that the action taken will not result in damage to the feature at a later date. The following are preservation repair treatments for iron lighthouses and lighthouses with iron components that can be undertaken after a thorough inspection.

Cleaning

The simple act of cleaning painted iron surfaces can effectively enhance the appearance and extend the life of the coating. In a marine environment a buildup of potentially corrosive elements such as salts, bird guano, and, in more urban locations, industrial pollutants can cause premature deterioration of iron components. Simple but effective regular cleaning will greatly extend the life of the iron components found on historic lighthouses. The following are guidelines to follow when cleaning historic iron lighthouse components:

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Figure 28. Surfaces such as this sheet-steel-covered parapet door that are covered with seagull guano should be thoroughly cleaned before mothballing and should be checked and cleaned once a year during the mothballing period.

- Clean surfaces only when necessary to remove buildup of corrosive agents such as salts, guano, and industrial pollutants that are causing damage to iron on the iron coating.
- Clean surfaces with the gentlest method possible, such as using low pressure water and mild detergents and natural bristle brushes. High pressure water blasting may damage caulking between iron components and force water into openings, leading to accelerated corrosion and deterioration.
- Do not use a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures within 48 hours of treatment.
- Do not clean with chemical products such as acids that will accelerate the corrosion of the iron components.

Paint Removal

When there is extensive failure of the protective coating and/or when heavy corrosion exists, the rust and most or all of the paint must be removed to prepare the surfaces for new protective coatings. The techniques available range from physical processes, such as wire brushing and grit blasting, to flame cleaning and chemical methods. The selection of an appropriate technique depends upon how much paint failure and corrosion has occurred, the fineness of the surface detailing, and the type of new protective coating to be applied. Local environmental regulations may restrict the options for cleaning and paint removal methods, as well as the disposal of materials.

Many of these techniques are *potentially dangerous* and should be carried out only by experienced and qualified workers using proper protective equipment such as full face respirators, eye protection, protective clothing, and optimum workplace safety conditions. Before selecting a process, test panels should be prepared on the iron to be cleaned to determine the relative effectiveness of various techniques. The cleaning process will very likely expose additional coating defects, cracks, and corrosion that were not obvious before.

There are a number of techniques that can be used to remove paint and corrosion from cast iron:

- ***Hand scraping, chipping, and wire brushing*** are the most common and least expensive methods of removing paint and light rust from iron. They do not however, remove all corrosion or paint as effectively as other methods. Experienced craftsmen should carry out the work to reduce the likelihood that surfaces will be scored or fragile detail damaged.
- ***Low-pressure grit blasting*** (commonly called abrasive cleaning or sandblasting) is often the

International Chimney photo

Figure 29. Worker dressed in full personal protective gear. The full-face-shield self-contained respirator provides both respiratory and eye protection. The worker is wearing protective coveralls, gloves, and boot covers to prevent lead dust contact. The harness is part of a full protection system. He is holding a pneumatic needle gun that is hooked to a two-stage HEPA (High Efficiency Particulate Air) filtered vacuum system.

SIDEBAR: Paint Removal Tools

A variety of hand tools are commercially available for the removal of paint from iron lighthouses. Typically, these tools are pneumatic or air powered and remove the paint from the iron substrate with rotating strippers and pulsating rods or needles. The rotating strippers consist of a shrouded, spindle-mounted head that has 3 or 4 "flaps" outfitted with metal studs that literally "knock" the paint off the iron surface. Commercially these tools are referred to as flush plates. This type of tool is best for the removal of paint from broad flat surfaces or curved surfaces with a radius of 5 inches or more. The tools with pulsating rods or needles typically consist of 12 to 15 hardened metal rods contained in a tube that strike the paint randomly as they pulsate. This action removes the paint by breaking or crushing it, thus breaking the bond with the iron substrate. Commercially these tools are referred to as needle guns or needle scalers. This type of tool is best for reaching tight-detailed locations such as around gallery deck brackets, etc.

The choice of one of these tools should depend on its impact on the historic iron substrate. Although iron is very hard, overly aggressive stripping methods can cause irreversible damage. Stripping tools should be tested in discrete locations to determine their effectiveness and potential impact on the historic iron substrate. In removing lead-based paint, these types of tools create both small chips and fine dust. To contain the dust and chips, the tools can be most effective approach to removing excessive paint buildup or substantial corrosion. Grit blasting is fast, thorough, and economical, and it allows the iron to be cleaned in place.

Grit blasting is performed by using compressed air to blow a grit at a high velocity through a hand held nozzle. The size and shape of the grit and the pressure of the compressed air determines the rate at which the paint and underlying substrate (iron or steel in this case) are removed.

Traditionally, the grit or abrasive used was sand. The use of sand for grit blasting has been discontinued because of the potential for the operator to develop silicosis. Today, a variety of grit mediums are available. These grits are typically derived from mineral slags and are available in a variety of grades engineered to produce the desired surface profile required by various iron and steel paint and coating systems. For more delicate applications a variety of alternative blast media are available. These include materials such as walnut shells,

outfitted with dust-collection hoods with vacuum hookup. As with any paint removal procedure, personal protective equipment required for health protection should be worn. Typical personal protective equipment includes eye/face protection, respiratory protection, gloves, coveralls, hard hat, and protection from falling if working 6 feet or higher above the ground (see Figure 29).

Figures 30 through 33 are paint removal tools used during the Sand Key Lighthouse rehabilitation. Sand Key Lighthouse is located in open water off the coast of Key West. The paint being removed contained lead; therefore it was essential that all debris be contained for proper disposal.

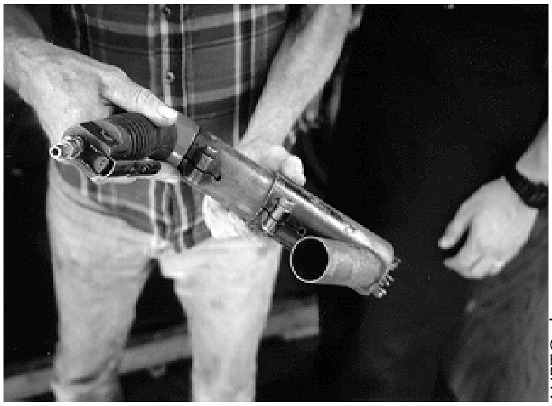
Figure 30. Close-up of a pneumatic needle gun. This tool works well for hard-to-reach and detail areas. The needle gun can be pressure-controlled to minimize impact on the iron substrate. This figure shows the vacuum-shroud connection on the right and air-hose connection on the base of the pistol-grip handle on the left.

Figure 31. The gun is activated by squeezing the lever on the rubber pistol grip. The amount of air pressure controls the speed and impact of the pulsating needles against the iron substrate. The needles can be seen protruding from the vacuum shroud.

Figure 32. Close-up view of a pneumatic flush-plate tool. During the Sand Key Lighthouse rehabilitation this tool was used for all flat surfaces and for removing paint from the light-tower columns. The rollers located at the top and bottom of the shroud guide the tool over the flat and curved surfaces. The amount of air pressure controls the speed and impact of the rotating head against the iron substrate. To contain the paint dust and chips, the shroud has been outfitted with a vacuum hookup.

WPTC photo

Figure 30.



WPTC photo

Figure 31.

WPTC photo

Figure 32.

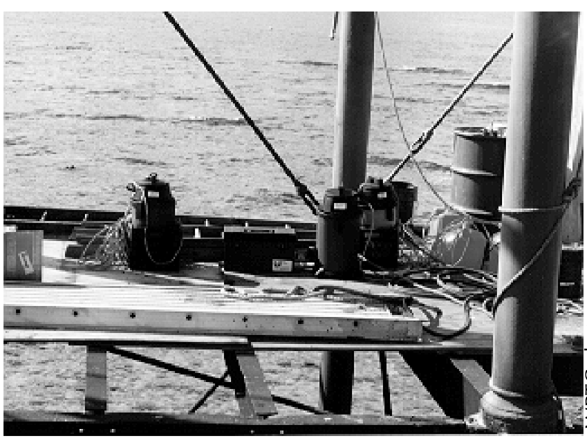
bicarbonate of soda, and frozen carbon dioxide (dry ice).

When selecting a grit media there are several factors to consider:

- A grit copper slag should be avoided because of the potential for electrolytic reactions that would corrode the iron surface.
- The grit medium should be chosen after testing has been performed to determine effectiveness of paint removal and potential impact or damage to the iron substrate, i.e., deep gouging or loss of detailed surfaces, and the surface profile produced.
- Do not use blast pressures above 100 pounds per square inch (psi). Keeping under 100 psi will still effectively remove the paint and help to minimize damage to the iron substrate.
- The environmental impact of the residue produced by the grit medium should be considered because many lighthouses are located in environmentally sensitive areas.

WPTC photo

Figure 33. Close-up of the studded flaps mounted on the rotating head. To use the tool, it is held against the face of the iron member and as the studded flaps spin they "slap" the surface and "knock" the paint off the iron.



WPTC photo

Figure 34. The small vacuums used at Sand Key Light are shown in this photo. Each vacuum has a HEPA filtration system to ensure that no lead dust escaped into the atmosphere. The conditions at Sand Key Lighthouse made the use of a large central vacuum system impractical. Using portable vacuums allowed for paint removal at numerous locations at any one time.

WPTC photo

Figure 35. This motorized chair was used to hoist workers as they removed paint from the cast-iron columns at the Sand Key Lighthouse. The chair's motor is attached to a hoist, so the chair actually climbs a cable that has been strung alongside the column.


WPTC photo


WPTC photo

Figures 36 and 37. The left image shows the condition of the iron exterior service room wall before rehabilitation. The right image shows the same area after power hand tool cleaning and coating. The crescent shaped scars in the iron are from the arc of a grinding wheel.

Some local building codes and environmental authorities prohibit or limit dry grit blasting because of airborne dust. To conform with local codes, the lighthouse may have to be tented during the removal to contain airborne paint and aggregate dust.

- Adjacent materials, such as brick, stone, wood, and glass, must be protected to prevent damage.

- ***Wet sandblasting*** is more problematic than dry sandblasting for cleaning iron because the water will cause instantaneous surface rusting and will penetrate deep into open joints. Therefore, it is generally not considered an effective technique. Wet sandblasting reduces the amount of airborne dust when removing a heavy paint buildup, but disposal of effluent containing lead or other toxic substances is restricted by environmental regulations in most areas.

- ***Flame cleaning*** of rust from metal with a special multi-flame-head oxyacetylene torch requires specially skilled operators, and is expensive and potentially dangerous. It can be very effective, however, on lightly to moderately corroded iron. Wire brushing is usually necessary to finish the surface after flame cleaning.

- ***Chemical paint removal*** using alkaline compounds, such as methylene chloride or potassium hydroxide, can be an effective


Bender & Associates, Architects

Figure 38. Service room bracket after chemical cleaning.

alternative to abrasive blasting for removal of heavy paint buildup. These agents are often available as slow-acting gels or pastes. Because they can cause burns, protective clothing and eye protection must be worn. Chemicals applied to non-watertight, multi-piece features (such as deck plates or wall plates) can seep through crevices and holes, resulting in damage to the lighthouse's interior finishes and corrosion to the backside of the iron components. If not thoroughly neutralized, residual traces of cleaning compounds on the surface of the iron can cause paint failures in the future. For these reasons, field application of alkaline paint removers and acidic cleaners is not generally recommended.

Following any of these methods of cleaning and paint removal, the newly cleaned iron should be painted immediately with a corrosion-inhibiting primer to prevent 'flash rusting' from forming. This time period may vary from minutes to hours depending on environmental conditions. Before application, paint or coating systems may require the iron or steel surface to be wiped with a solvent that removes any microscopic rust that has formed on the surface.

The buildup of salt or chloride residue on bare metal surfaces will affect the paint or coating performance. The metal surface should be tested for chloride buildup from the salt-laden air found in a marine environment. If chloride levels are above levels recommended by the paint or coating manufacturer, the surface will need to be wiped with a solvent to remove the chloride buildup.

If priming is delayed, any surface rust that has developed should be removed with a clean wire brush just before priming. The rust prevents good bonding between the primer and the cast-iron surface and may also prevent the primer from completely filling the pores of the metal.

External Coating Systems

The most common and effective way to preserve iron lighthouse components is to maintain a protective paint or coating on the metal.

The effective protective life span of an existing paint or coating can be greatly increased by routinely touching up areas of deterioration. A small break in the protective finish can lead to accelerated corrosion of the underlying iron (see Figure 39). Areas where the paint or coating has been damaged by mechanical impact or blistering has occurred should be addressed immediately. These areas should have all loose paint and rust scale removed using one of the recommended methods

WPTC photo

Figure 39. The finish on this tension rod failed and localized corrosion (rust) has formed. The rust is exfoliating in layers that are trapping moisture and causing corrosion to occur deeper and deeper into the tension rod. The result is pitting that will compromise the strength of the tension rod. If the area had been touched up in time, the corrosion might not have formed.

previously described. Hand tool cleaning and low pressure grit blasting are the most effective for this scale of paint removal. The bare metal should then be primed and painted with a primer/top coat system that will adhere to both the bare metal and the existing paint or coating system. The top coat should match the existing color to maintain the lighthouse daymark.

Surface Preparation

Thorough surface preparation is necessary for the adhesion of new protective coatings. All loose, flaking, and deteriorated paint must be removed from the iron, as well as dirt and mud, water-soluble salts, oil, and grease. Old paint that is tightly adhered may be left on the surface of the iron if it is compatible with the proposed coatings. The retention of old paint also preserves the historic paint sequence of the building and avoids the hazards of removal and disposal of old lead paint.

It is advisable to consult manufacturer's specifications or technical representatives to ensure compatibility between the surface conditions, primer and finish coats, and application methods. If the composition of the existing paint or coating is not known, then a thorough analysis should be performed to determine composition of the existing coating to ensure compatibility with the future paint or coating. For more information refer to the Steel Structures Painting Council publication—*Steel Structures Painting Manual*.

When painting new stainless steel or other new steel or iron surfaces, special surface preparation steps must be taken. Typically these surfaces have a shop coating of light oil applied to prevent rusting. This oil must be removed with a solvent before painting. The surfaces of these materials may not have the right profile or roughness for the applied coating to adhere. To achieve the

WPTC photo

Figure 40. The paint on this stainless steel replacement gallery deck has begun to peel less than three months after it was painted. This could have been prevented if the stainless steel parts were first cleaned and then lightly glass-bead blasted.

proper profile, the surfaces should be lightly grit blasted with glass beads to achieve the profile recommended by the manufacturer.

For the paint to adhere properly, the metal surfaces must be absolutely dry before painting. Unless the paint selected is specifically designed for exceptional conditions, painting should not take place when the temperature is expected to fall below 50 degrees Fahrenheit within 24 hours or when the relative humidity is above 80%; paint should not be applied when there is fog, mist, or rain in the air. Poorly prepared surfaces will cause the failure of even the best paints, while even moderately priced paints can be effective if applied over well-prepared surfaces.

Selection of Paints and Coatings

The types of paints available for protecting iron have changed dramatically in recent years as the result of federal, state, and local regulations that prohibit or restrict the manufacture and use of products containing toxic substances such as lead and zinc chromate, as well as volatile organic compounds and substances (VOC or VOS). Availability of paint types varies from state to state, and manufacturers continue to change product formulations to comply with new regulations.

Traditionally, red lead has been used as an anti-corrosive pigment for priming iron. Red lead based paint forms a tough and elastic film impervious to water that is highly effective as a protective coating for iron. At least two slow-drying linseed-oil-based finish coats have traditionally been used over a red lead primer; this combination is effective on old or partially-deteriorated surfaces.

Today, alkyd paints are very widely used and have largely replaced lead-containing linseed-oil paints. They dry faster than oil paint, with a thinner film, but they do not protect the metal as long. Alkyd rust-inhibitive primers contain pigments such as iron oxide, zinc oxide, and zinc phosphate. These primers are suitable for previously painted surfaces cleaned by hand tools. At least two coats of primer should be applied, followed by alkyd enamel finish coats.

Latex and other water-based paints are *not* for use as primers on cast iron or steel because they cause immediate oxidation if applied on bare metal. Vinyl acrylic latex or acrylic latex paints may be used as finish coats over alkyd rust-inhibitive primers, but if the primer coats are imperfectly applied or are damaged, the latex paint will cause oxidation of the iron. Therefore, alkyd finish coats are recommended over alkyd primer.

High-performance coatings, such as zinc-rich primers containing zinc dust, urethane based coatings and modern epoxy coatings, can be used on cast iron to provide longer-lasting protection. These coatings typically require highly clean surfaces and special application conditions.

One particularly effective system has been developed to coat commercially blast-cleaned iron with a zinc-rich primer, followed by an epoxy base coat, and two urethane finish coats. Some epoxy coatings can be used as primers on clean metal or applied to previously painted surfaces in sound condition. Epoxies are particularly susceptible to degradation under ultraviolet radiation and must be protected by finish coats which are more resistant. There have been problems with epoxy paints which have been shop-applied to iron where the coatings have been nicked before installation. Field touch-up of epoxy paints is very difficult, if not impossible. This is a concern since iron exposed by imperfections in the base coat will be more likely to rust and more frequent maintenance will be required.

In recent years, moisture-cured urethane coating systems have begun to take the place of epoxy-based coating systems. Moisture-cured urethane coatings are more surface tolerant, can be used in lower temperatures, and can be applied and work better at higher humidities than epoxy-based coatings. Moisture-cured urethane coatings, however, have a tendency to thicken quickly under humid conditions and have the potential of being applied too thickly, resulting in a loss of the character-defining features of the substrate.

A key factor to take into account in selection of coatings is the variety of conditions affecting existing and new materials on a particular lighthouse. One primer may be needed for surfaces with existing paint; another for newly cast, chemically stripped, or blast-cleaned cast iron; and a third for flashing or substitute materials—all three followed by compatible finish coats.

Another factor to consider when choosing a high performance coating is that these coatings tend to have a high gloss finish that is slippery when wet. When painting gallery decks and other iron or steel walkways, anti-skid strips may need to be installed for personnel or visitor safety.

SIDEBAR: Masonry and Iron Interaction

A common practice in masonry lighthouse construction is to use iron door and window hoods, gallery deck brackets, belt courses, and water table caps. These details are both decorative and structural components of the lighthouse; however, they pose special preservation issues. The iron that is in contact with the masonry tends to corrode more readily than the rest of the iron component. This condition is typically evidenced by rust streaks on the masonry surface (see Figures 41 and 42). This rusting is caused by moisture either from condensation or precipitation combined with chloride or salt buildup that collects in the joint. If the joint is not sealed and the coating on the iron is failing, rust will readily form.

This condition can easily be remedied if the following issues are addressed during the preservation treatment of the lighthouse. During any repairs or repainting, all masonry and iron surfaces must be cleaned of all loose paint and rust scale. All mortar that has been placed between the masonry and the iron should also be removed. The mortar helps trap moisture against the iron. Once the joint is clean, all exposed iron must be coated with a rust-inhibiting primer and top coat to provide a barrier between the iron and the mortar. The void created by the missing mortar should be filled with a new mortar mixture that matches the strength of the historic mortar (for more information on the matching of mortar strength refer to the **Masonry** section). When filling the open joint with the mortar, hold the mortar back about 1 inch. The joint should then be filled with a ½-inch-diameter polyethylene foam backer rod. To seal the joint, use a high quality silicone or urethane caulking. (Some caulks may require a painted surface to adhere to brick; therefore, the surface of the brick that will come in contact with the caulk may have to be painted before the caulk is applied). Ideally, the caulking depth should equal the joint depth up to a ½ inch. The profile on the caulking should be slightly concave to shed water. Refer to Figures 43 and 44 for more details.

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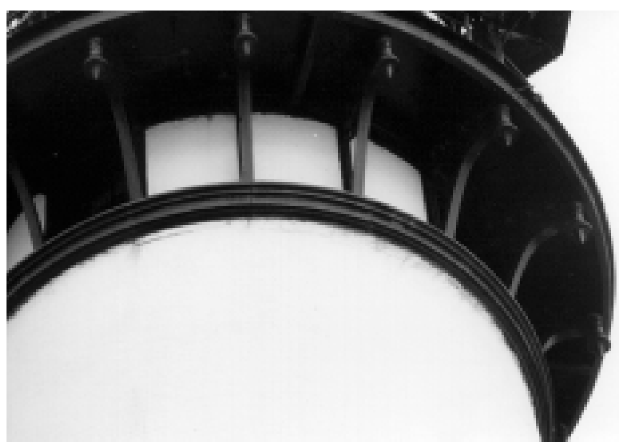


WPTC photo

Figure 41 (left). This masonry lighthouse has been detailed with a two-tier cast-iron water table (the iron portions are painted black). Rust-bleed is occurring along lower edge of the upper tier.

Figure 42 (above). The lower gallery deck of the same masonry lighthouse has rust-bleed occurring along the lower edge of the iron belt course that supports the gallery deck brackets.

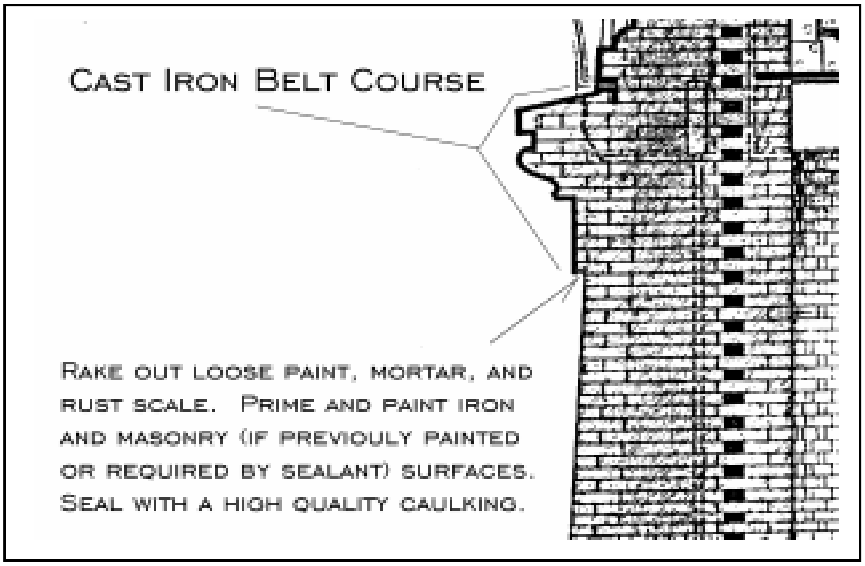


Figure 43.

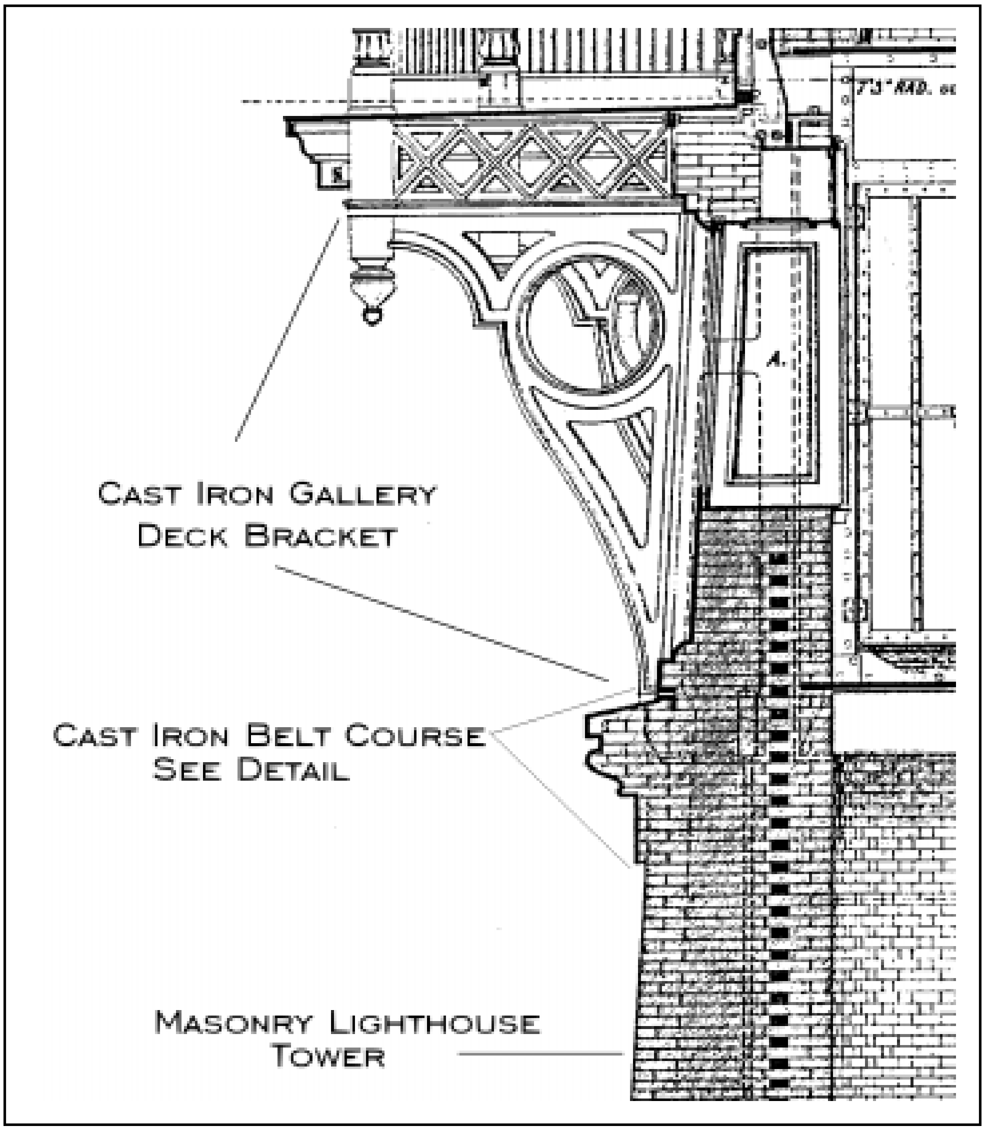


Figure 44.

Application Methods

Brushing is the traditional and most effective technique for applying paint to iron. It provides good contact between the paint and the iron, as well as the effective filling of small pits, cracks, and other blemishes in the metal. The use of spray guns to apply paint is economical, but does not always produce adequate and uniform coverage. For best results, airless sprayers should be used by skilled operators. To fully cover fine detailing and reach recesses, spraying of the primer coat, used in conjunction with brushing, may be the most effective application method. During application, all overspray must be contained; this may be achieved by tenting the lighthouse. Because of the potential for overspray drift and its environmental impact, the industry standard for lighthouse painting is to use brushes.

Rollers should never be used for primer coat applications on metal and are effective for subsequent coats only on large, flat areas. The appearance of spray-applied and roller-applied finish coats is not historically appropriate and should be avoided on land-based lighthouses which are viewed up close by the public.

Caulking, Patching, and Mechanical Repairs

Most iron components on historic lighthouses were made of many small castings assembled by bolts or screws. Joints between pieces were caulked to prevent water from seeping in and causing rusting from the inside out. Historically, the seams were often caulked with white lead paste and sometimes backed with cotton or hemp rope; even the bolt and screw heads were caulked to protect them from the elements and to hide them from view. Although old caulking is sometimes found in good condition, it is typically crumbled from weathering, cracked from structural settlement, or destroyed by mechanical cleaning. It is essential to replace deteriorated caulking to prevent water penetration. For good adhesion and performance, an architectural-grade polyurethane sealant is preferred. For a more in-depth discussion of various types of caulking compounds refer to the **Windows** section.

Water that penetrates the hollow parts of iron components causes rust that may streak down over other elements of the lighthouse. The water may freeze and the expanding ice may crack the cast iron. Cracks reduce the strength of the total cast-iron assembly and provide another point of

WPTC photo

Figure 45. Within three months after painting, the rust began to bleed through this weep hole on the bottom of this pediment bracket. Two lessons are to be learned from this condition: 1) keep weep holes open to allow any water that may have entered the casting to escape, and 2) keep joints around applied castings sealed; apparently this was not done and water has entered the hollow cavity of the pediment, causing rust to form inside.

entry for water. Water entering seams may also cause rust to form within the joint and damage the surrounding iron through a process known as 'rust-jacking'. Thus, it is important that cracks be made weathertight by using caulks or fillers, depending on the width of the crack.

Filler compounds containing iron particles in an epoxy resin binder can be used to patch superficial, non-structural cracks and small defects such as rust pits in cast iron. The thermal expansion rate of epoxy resin alone is different from that of iron, requiring the addition of iron particles to ensure compatibility and to control shrinkage. Although the repaired piece of metal does not have the same strength as a homogeneous piece of iron, epoxy-repaired members do have some strength. Polyester-based putties, such as those used on auto bodies, are also acceptable fillers for small holes. For more information on metal paste use in lighthouse restoration, refer to the Point Bonita Lighthouse rehabilitation case study in the Part V., **Beyond Basic Preservation**.

In rare instances, major cracks can be repaired by brazing or welding with special nickel-alloy welding rods. Brazing or welding of cast iron is very difficult to carry out in the field and should be undertaken only by very experienced welders.

In some cases, mechanical repairs can be made to cast iron using iron bars and screws or bolts. In extreme cases, deteriorated cast iron can be cut out and new cast iron spliced in place by welding or brazing. It is frequently less expensive, however, to replace a deteriorated cast-iron section with a new casting rather than to splice or reinforce it. Cast-iron structural elements that have failed must either be reinforced with iron and steel or replaced entirely.

Screws with stripped threads and seriously rusted bolts must be replaced. To compensate for corroded metal around the bolt or screw holes, new stainless steel bolts or screws with a larger diameter need to be used. In extreme cases, new holes may need to be tapped.

The internal voids of hollow iron lighthouse components should not be filled with concrete; it is an inappropriate treatment that causes further problems. As the concrete cures, it shrinks, leaving a space between the concrete and cast iron. Water penetrating this space does not evaporate quickly, thus promoting further rusting. The corrosion of the iron is further accelerated by the alkaline nature of concrete. Where iron components have been previously filled with concrete, they need to be taken apart, the concrete and rust removed, and the interior surfaces primed and painted before the components are reassembled.

Flashing

In some instances, it may be necessary to design and install flashing to protect areas vulnerable to water penetration. Flashings should be designed and fabricated carefully so that they are effective, as well as unobtrusive in appearance. The most durable material for flashing iron is terne-coated stainless steel. Other compatible materials are terne-coated steel and galvanized steel; however, these require more frequent maintenance and are less durable. Copper and lead-coated copper are not recommended for use as flashing in contact with cast iron because of galvanic corrosion problems. Galvanic problems can also occur with the use of aluminum if certain types of electrolytes are present.

Dismantling and Assembly of Iron Components

If repairs cannot be successfully carried out in place, it is sometimes necessary to dismantle all or part of a cast iron lighthouse structure during restoration. Dismantling should be done only under the direction of a preservation architect or architectural conservator who is experienced with historic cast iron. Extreme care must be taken since cast iron can be brittle, especially in cold weather.

Dismantling should follow the reverse order of construction and re-erection should occur, as much as possible, in the exact order of original assembly. Each piece should be numbered and keyed to record drawings. When work must be carried out in cold weather, care needs to be taken to avoid fracturing the iron elements by uneven heating of the members. Both new castings and reused pieces should be painted with a shop-applied prime coat on all surfaces. All of the components should be laid out and preassembled to make sure that the alignment and fit are proper. Many of the original bolts, nuts, and screws may have to be replaced with similar fasteners of stainless steel.

After assembly at the site, joints that were historically caulked should be filled with an architectural-grade polyurethane sealant or the traditional white lead paste. White lead has the advantage of longevity, although its use is restricted in many areas.

Limited Replacement In Kind

The replacement of cast-iron components is often the only practical solution when such features are missing, severely corroded, or damaged beyond repair, or where repairs would be only marginally useful in extending the functional life of an iron element. For more information on replacement iron or steel lighthouse components refer to the case studies in Part V., **Beyond Basic Preservation**.

SIDEBAR: Lighthouse Designer/Builder George Meade

General George Gordon Meade is famous to most people as the commander of the Army of the Potomac which defeated General Robert E. Lee at the Battle of Gettysburg in 1863. But to lighthouse enthusiasts, Meade is famous for his lighthouse work, specifically Florida Reef screwpile lighthouses. A screwpile is a screw-like flange located on the end of a lighthouse foundation pile, which when wound into the substrate, provided greater holding power than a straight-pile. The first screwpile lighthouse in the United States was at Brandywine Shoal, Delaware Bay, built by Major Hartman Bache, a distinguished engineer of the Army Corps of Topographical Engineers. Work began in 1848 and was completed in 1850, with construction cost at $53,317. Alexander Mitchell, an Englishman who invented the screwpile principle, served as consultant. The screwpiles were turned by a four-foot capstan worked by 30 men. Major Bache also built the second screwpile lighthouse in the United States with construction of the Pungoteague River Lighthouse, Chesapeake Bay, built in 1854.

George Meade was also an engineer in the Army Corps of Topographical Engineers. He worked with Bache designing and constructing screwpile foundation lighthouses in Delaware Bay. Meade was also asked to survey and chart the Florida Reefs. The first screwpile skeletal lighthouse to be built on this dangerous stretch of reefs between Cape Florida and Key West was the Carysfort Reef Lighthouse, located off Miami and designed by I. W. P. Lewis. The

NMI photo

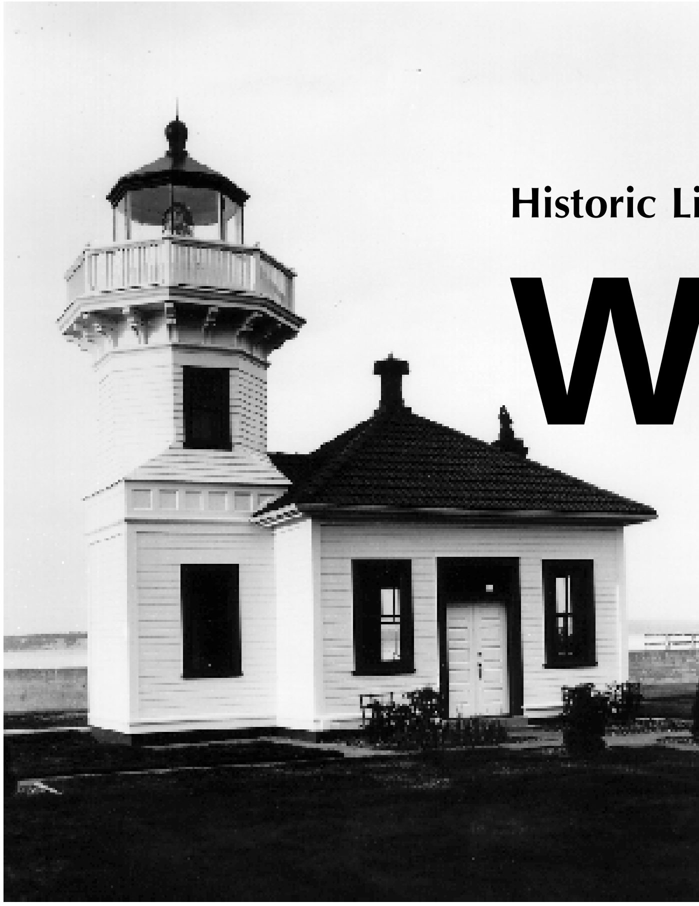
Figure 46. Bust of George Meade at Barnegat Lighthouse, Long Beach, New Jersey.

entire structure was first erected in Philadelphia "so as to obviate the necessity of fitting parts at its isolated site." It cost $105,069 to complete. When the engineer in charge of the Carysfort Reef Lighthouse project died, Meade, now a lieutenant, was assigned the task of completing the job. This was the first of what was to become many lighthouse jobs for which Meade had total responsibility. Carysfort Reef Lighthouse was successfully completed in 1852. The offshore Carysfort Reef Lighthouse is believed to be the first screwpile skeletal tower in the U.S. to use foot plates or disks to help disperse the weight of the tower over a broader foundation base.

Two months after completing Carysfort Reef Lighthouse, Meade was asked to inspect the site selected for the Rebecca Shoal screwpile lighthouse, also in the Florida Keys. Meade commented that "no beacon of any kind had been erected, either in the United States or in Europe, in a position that is more exposed or offered greater obstacles." His wrought-iron skeleton light tower was nearly completed when a three-day storm completely carried away the structure. A second attempt was so severely racked by the pounding seas that the piles worked out of the sand and it collapsed. The Lighthouse Board abandoned the lighthouse project and marked the shoal with buoys.

Meanwhile Meade went on to complete the 132-foot-tall screwpile Sand Key Lighthouse in 1853 and the 142-foot-tall screwpile Sombrero Key Lighthouse in 1858, also in the Florida Keys. One historian stated that Sombrero Key was the most important lighthouse built by Meade. Meade also designed a five-wick, first-order, hydraulic lamp which was adopted by the Lighthouse Board in about 1853. Meade was placed in charge of both the Fourth and Seventh Lighthouse Districts. In 1855 Meade surveyed the Barnegat Lighthouse, New Jersey, which had received many complaints by mariners. His suggestion that the tower needed to be replaced with a first-order coastal tower was approved; the present Barnegat Lighthouse was completed in 1859. Meade also supervised construction of the 167-foot-tall brick Absecon Lighthouse, Atlantic City, New Jersey, completed in 1857. In 1860 Meade was transferred from Florida to direct the surveys of the Northern Lakes, but with the advent of the Civil War, Meade requested and received active military service. He was promoted to brigadier general of the Pennsylvanian Volunteers and in June 1863 became commander of the Army of the Potomac.

While there are many monuments to George Meade because of his military achievements, few people are aware of a monument commemorating his lighthouse work. At the base of the Barnegat Lighthouse is a bronze bust of Meade and a dedication plaque. Ironically, even fewer people are aware of Meade's most important lighthouse contribution; his work with Florida Reef screwpile lighthouses.



Historic Lighthouse Preservation:

WOOD

Figure 1. Wooden Mukilteo Light Station in Mukilteo, Washington.

Wood was the third most common building material used in historic lighthouse construction. As a general rule the first towers at early light station sites were constructed of wood and were used until funds were available to build a more durable structure of masonry or iron. In some locations, however, the wood tower remained or was chosen as the permanent lighthouse structure.

Easily shaped by sawing, planing, carving, and gouging, wood was used for virtually all components of historic lighthouses. Wooden towers were generally timber frame construction covered with sheathing and clapboards or shingles. All other lighthouse components such as door and window surrounds, cornices, deck railings, decking, doors and windows were also constructed of wood. The use of wood in lighthouse construction, however, was not limited to the structure. Many masonry and iron lighthouses were fitted with wooden parts. For example, a common Chesapeake Bay lighthouse configuration is a masonry tower fitted with wooden interior stairs and wooden tongue-and-groove beadboard lantern parapet walls. All wooden components, both functional and decorative, may be important in defining the historic character of a lighthouse. The retention, protection, and repair of these features is important during any preservation treatment.

Although wood is not as durable as iron or stone, with proper preservation care, wooden structures can last virtually forever. As with all materials, the expected life span of wood can be significantly shortened if maintenance is deferred or treatments cause damage to the wood.

NMI photo

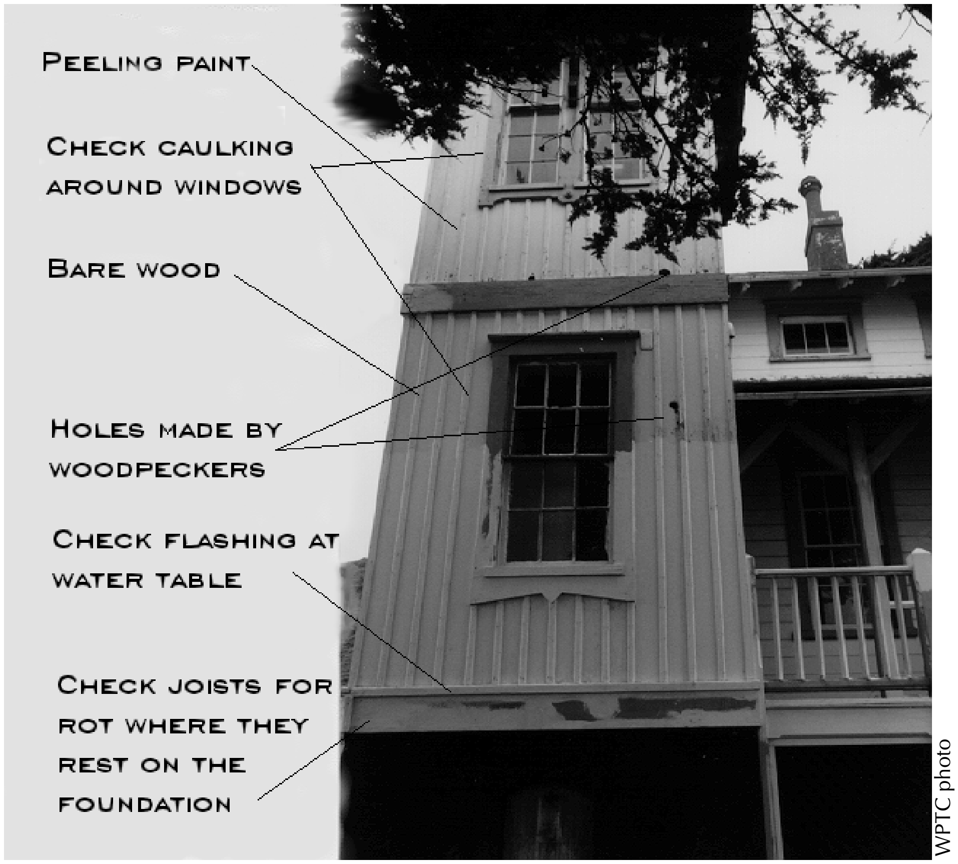
Figure 2. Wooden Point Fermin Light Station in San Pedro, California.

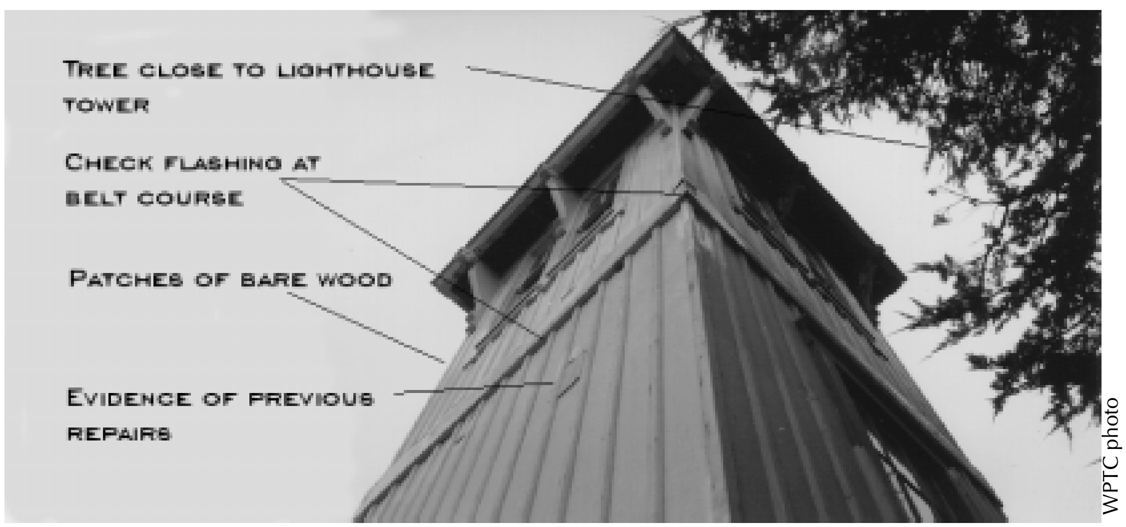
Why Does Wood Deteriorate?

Wood in a marine environment is subject to a host of forces. How successfully a wooden lighthouse resists these pressures depends on how well it is designed and maintained.

Leading causes of wood decay:

- inherent design flaws or missing/damaged features that allow for the exposure of wood end grain to moisture or allow water to puddle or collect on wooden components;
- lack of trim elements and metal flashing to protect the wood elements by shedding water away from the lighthouse;
- failed coating systems that allow raw wood to come in contact with moisture;
- moisture trapped within a cavity defined by wooden components such as within a wall; and
- attack by fungus, insects, or other pests.





Figures 3 and 4.

Inspecting for Problems Associated with Wooden Lighthouses

In order to develop an effective treatment plan for problems associated with wooden lighthouses and their components, an in-depth inspection should be made of the lighthouse and its immediate surroundings. The following chart is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Wooden Lighthouses	
THE SITE	
Look For:	*Possible Problems:*
Environment	
General climatic conditions, including average temperatures, wind speeds and directions, humidity levels, and average snow accumulation	Severe conditions can lead to wooden lighthouse component deterioration, including cracking, coating failure, and severe weathering.
Number of freeze-thaw cycles	Severe cycles can produce damage from frost action that can cause wooden lighthouse components to crack and split, as well as premature coating failure.
Location near sea	Salt in the air can lead to severe chalking of the paint surface and cause premature failure of latex paint products.
Acid rain in the region or from nearby industry	Acid rain can accelerate the deterioration of paint and exposed wood surfaces.
Proximity to a major road highway or railroad	Vibrations are harmful to mortar joints and other lighthouse parts.
Location in the flood plain of a river, lake, or sea	Floodwaters can bring damaging moisture in contact with wooden lighthouse components.
Exposed or sheltered sections of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration. In damp climates mildew and other fungal growth tends to grow on the north side of the lighthouse and under gallery decks where the surface never receives direct sunlight.
Terrain	
Soil type—clay, sand, rock	The type of soil influences water drainage around the structure. Excessive water in the soil can cause rising damp within the foundation, permitting moisture to migrate into adjacent wooden lighthouse components.
Slope away from lighthouse on all sides	If no slope exists, puddles will form at the base of the lighthouse walls during heavy rains, leading to water penetration and splash-back. Splash-back can cause localized saturation of the wooden lighthouse walls, which will cause premature paint or coating failure.
Earth covering part of a brick or stone wall or foundation	Moisture accumulation or penetration is possible which in turn can migrate into adjacent wooden lighthouse components.

Look for:	*Possible Problems:*
Asphalt or other impervious paving touching walls	Water accumulation and rain splash-back onto the walls can result, causing wood members to be constantly saturated. This condition will
encourage premature rotting and deterioration.	
Trees and Vegetation	Species of trees with 50 feet
Elms and some poplars dry up clay soil, leading to	possible lighthouse foundation failure.
Branches rubbing against a wall	Branches abrade surfaces and cause premature coating failure.
	Ivy or creepers on walls
	Leaves prevent proper drying of the painted surface
which can lead to mildew and prolonged damp conditions. Tendrils from some species can penetrate joints in the wooden sheathing members and may ultimately cause the failure of the wooden lighthouse component.	
THE LIGHTHOUSE	**Overall Condition**
General state of maintenance and repair	A well maintained lighthouse should require fewer major repairs.
Evidence of previous fire or flooding	Such damage may have weakened the wooden lighthouse structure members or caused excessive moisture.
Consistent wall plane	
A crooked wall may be a sign of stabilized	structural settlement as well as unstable foundations and may possibly lead to partial or total lighthouse collapse.
Lantern	Gallery decks
	Gaps in gallery decking (cast-iron plate, flat-seam metal) and wood tower wall copings can allow water to penetrate the interior cavities of wood
frame lighthouse walls.	Condition of lantern storm panels
	Cracks and holes in storm panel glazing can provide an infiltration point for moisture into the lantern thus affecting the interior wooden

components: stairs and interior parapet wall covering.	
Wood parapet walls	Holes or damaged flashings could allow water to penetrate the wall cavity causing the wood to deteriorate from the inside out, as well as cause corrosion on the interior iron structural members.
	Look for:
Possible Problems:	
Humidity level within the lantern	Non-functioning lantern vents can prohibit the release of humid air from within the tower. The
water vapor will ultimately condense on the surfaces inside the tower and lantern. Growth of mildew and fungus will result, thus causing premature deterioration of the wooden features.	**Windows and Doors**
Straight and square openings	Deformed openings are a sign of lighthouse structural settlement.
Sills sloped to shed water; drips under sills to prevent water from running back underneath; caulking	
If any of these are inadequate, water can penetrate	into the lighthouse wall.
	Gaps around perimeter of the window frame
Moisture infiltration will result, causing premature	deterioration of the wood structural framing and wood window frame.
	Foundation
Composition of foundation walls	Stone or brick is more likely than concrete to allow water to infiltrate and possibly allow moisture to migrate into adjacent wooden
lighthouse components.	
Water condensation or other signs of moisture	Wood joists resting on masonry foundation walls may begin to rot at the ends. Termites, mold, mildew, moss, or algae may be present, causing
damage to the wood.	Rising damp can cause deterioration of the
Damp proof course masonry wall and adjacent wood lighthouse components.	
Interior	Cracked plaster, signs of patching, floors or landings askew
These are signs of lighthouse settlement and possibly deteriorated wooden structural components.	Damp walls, mold and mildew stains on walls, rotting wood

These indicate water infiltration.	
Walls	
Construction method—heavy timber or light frame; load bearing or not load bearing	
Knowing how a lighthouse tower wall is constructed will help in analyzing problems and	selecting appropriate treatments.
	Evidence that parts of the lighthouse were constructed at different times or of different materials
	Similar problems with various parts may need
different treatments because of different materials.	*Look for:* *Possible Problems:*
Wood Components	**Materials**
	Wood species, dimensions, and character defining
marks, textures, etc. where the deteriorated wood component is in	Types of materials indicate the susceptibility or resistance to damage and should be matched if wood must be replaced. In hidden locations contact with stone or subjected to moisture, substitute materials such as preservative treated lumber may be used.
Areas of delicate carving or fine moldings	
These are typically character-defining features of	the lighthouse that will need special attention or protection during rehabilitation.
	Missing or broken foundation bricks or stones,
exterior wood siding, shingles, trim, etc.	Missing material may allow water penetration that could cause damage to the lighthouse's internal structural framing.
	Evidence of high pressure waterblasting, such as eroded surfaces, flaking, scaling, or crazed paint
Damaged and deteriorated surfaces can allow	water to penetrate and promote rapid degradation of wood lighthouse components.
	Dirt or stains
	Surface stains usually cause few problems other than being unpleasant to look at. Mildew growth

is a sign of damp conditions.	

Bulges and Cracks

Bulges Bulges indicate that the wall has moved because of possible wooden structural component failure or deterioration. Corrective action may be	necessary.
Cracks in interior or exterior wall covering indicate movement has occurred within the wall.	Cracks Small cracks may be patched; large cracks may require reconstruction of the affected area. A full inspection of structural members should be performed if cracks are present.
Enlarging cracks/active movement	Active cracks in interior plaster wall covering indicate a continuing problem. The cause must be dealt with before the crack itself is repaired. Cracks that are assumed to be the result of active movement should be monitored to determine

level of activity and to properly address the problem.

Look for:	*Possible Problems:*

Moisture

Water penetration through joints between masonry masonry and the wooden lighthouse components of the structure.	foundations and wooden lighthouse components, i.e., along mudsill Moisture can lead to deterioration of both the Water penetration between the lantern gallery deck and the wooden lighthouse structure

Moisture can lead to deterioration of both the iron components and the wooden components of the lighthouse.

	Exposed end grain of window and door frame members, trim components, and decking
infiltration; exposed end grain tends to actually draw or wick water through capillary action. End	All end grain is susceptible to moisture grain must be protected at all times by a well maintained coating system or by inherent trim detailing.

Coatings

Paint; type of paint

Latex paint products do not withstand the severe conditions experienced in the marine environment as well as oil-based products.

Blistering paint

Paint that blisters off the wood substrate in large sheets is a sign of moisture infiltration within the wood itself; the escaping moisture actually 'pushes' the paint off the wood.

Flaking, peeling, and crazed paint

This is usually a sign that the paint has lost its flexibility and is beginning or has already begun to

PRESERVATION TREATMENTS

Protection and Stabilization (Mothballing)

Although seemingly less durable when compared to masonry or iron, wooden lighthouses can last almost indefinitely if they are properly protected and stabilized. To properly protect and stabilize a historic wooden lighthouse, a thorough inspection and diagnosis should be performed using the inspection chart in the preceding section as a guide. Use the results of the inspection to develop a protection and stabilization plan. The following recommended protection and stabilization guidelines for vacant historic masonry lighthouses are minimum treatment requirements to prevent any further damage from occurring.

Weatherization

When a wooden lighthouse is mothballed, the exterior envelop should be completely weathertight. Moisture penetrating into wooden walls can be exceedingly detrimental to the integrity of the structure. Moisture within the wooden elements of a wall may cause various types of damage. High moisture content may literally "push" paint off the face of the wooden component, encourage fungal growth that will cause the wood to decay and rot, or attract termites and other wood eating insects that will cause rapid deterioration of the wooden components.

To prevent moisture penetration, be sure the following infiltration points are weathertight or functioning properly:

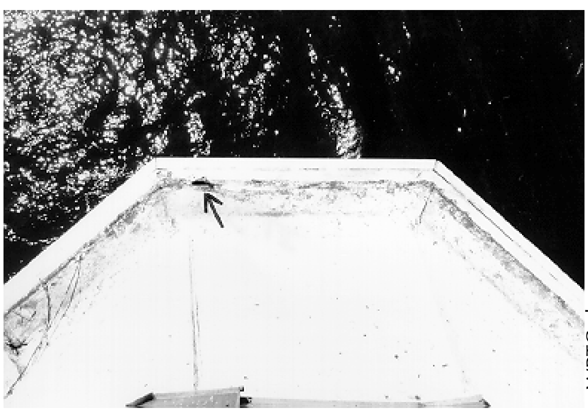
- ***Lantern glass:*** Lantern glass, frames, and roofs must be weathertight before mothballing (see Figure 5). Refer to the **Lantern** section for more information concerning the weatherproofing of the lantern components.
- ***Built-in guttering systems:*** All rainwater guttering systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. Water entering the structure will cause premature deterioration of internal structural components. For more information refer to the discussion on roofing in the **Lantern** section.
- ***Gallery decks:*** In most wooden lighthouses gallery decks are wood covered in sheet metal. These decks are generally laid directly on top of the wooden wall structure. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior cavity of the wall. Refer to the **Lantern** section for more information concerning the weatherproofing of gallery decks.

Figure 5. Storm glass with holes should be replaced as soon as possible to minimize water infiltration. If immediate replacement is not an option, the storm glass can be temporarily patched.

Figure 6. An acceptable temporary lantern glass repair made using a small piece of sheet metal and caulking.

WPTC photo

Figure 7. Ponding is occurring on this gallery deck near the base of the lantern parapet wall. This ponding has led to an active leak that occurs even during light rain conditions. A condition such as this should be remedied before the mothballing period.



WPTC photo

Figure 8. View of a wood-framed lighthouse roof; the arrow indicates where a large hole (approximately 2 by 4 inches) is present in the built-in gutter system. Water entering this hole has caused extensive damage to the interior wood framing members and wood interior wall paneling.

WPTC photo

Figure 9. If the exterior of the wooden tower has been covered with another sheathing material like this corrugated metal, all joints in the exterior sheathing should be made completely weathertight; at this particular lighthouse, deterioration of interior wood framing members was caused by moisture infiltration.

WPTC photo

Figure 10. This door sill has a positive slope to ensure proper drainage; the joint where the door surround meets the shingles should be checked for gaps and recaulked if necessary.

- ***Door and window frames:*** The joints along the perimeter of door and windows where a wood or metal frame is fitted into a wall opening should be caulked to prevent moisture from entering the walls. Both door and window sills should have a positive slope to ensure water is drained away from the door or window opening. See the **Windows** and **Doors** sections for the proper caulk for this application.

- ***Loose or open joints:*** If the seams between siding boards are open or if the putty in those joints is loose, moisture can penetrate. In order to prevent this infiltration, all putty that is in disrepair must be removed and the affected seams sealed with caulking. For more information on various types of caulking available, refer to the **Windows** section.

- ***Protective coatings:*** Lighthouses were historically painted as a protective measure and for identification as a daymark. As part of a mothballing treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color. Ultimately, as part of a mothballing treatment the entire lighthouse should have all loose and flaking paint removed and a new coating applied according to the manufacturer's specifications. This action will result in a coating system that will require minimal service during the mothballed period. In lieu of a total repainting, spot painting can be an effective alternative. The removal of loose and flaking paint followed by spot priming and painting areas of bare wood will greatly increase the effective life span of a wooden lighthouse. For more information refer to the discussion on repainting under the **Repair** treatment in this section.


WPTC photo

Figure 11. Open joints like those between these skirt boards must be properly primed, painted, and filled before mothballing the lighthouse.

Stabilization

When mothballing a wooden lighthouse, all possible structural repairs should be made before the official beginning of the "mothballed" period. If budget constraints prevent repairs, structural stabilization is the next option. Temporary wood shoring of window and door openings, installation of interior or exterior shoring, or bracing are all stabilization methods. A structural engineer or historical architect should be consulted for a proper stabilization treatment plan. The stabilization treatment utilized should not permanently damage features that define historic character. The treatment should also be easily reversible so that when the budget allows, the structure can be properly repaired.

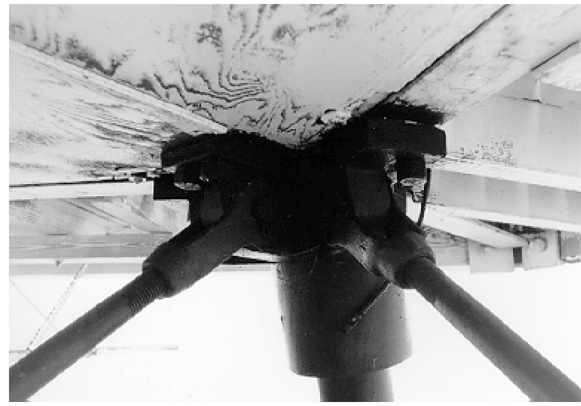

WPTC photo

Figure 12. View of underside of a screwpile lighthouse. Although these bare wood surfaces are not directly exposed to rain, they are susceptible to mist and condensation moisture; and because there is no exposure to direct sunlight, the surfaces are seldom dry. For adequate protection during the mothballing period, these surfaces should be painted.

Ventilation

When the exterior has been made weathertight and secure, it is essential to provide adequate air exchange throughout the lighthouse. Once closed up, a lighthouse interior will still be affected by the temperature and humidity of the exterior. Without proper ventilation, moisture from condensation may occur and cause damage by wetting plaster, peeling paint, staining woodwork, warping floors, and in some cases even causing freeze-thaw damage to plaster. If moist conditions persist in a wooden lighthouse, structural damage can result from rot or returning insects attracted to moist conditions.

The average required minimum air exchange for most mothballed lighthouses is one to four air exchanges every hour; in the winter one or two air exchanges per hour. Twice this amount is typically required in the more humid summer months. In order to achieve this, almost every window opening will need to be fitted with some type of passive, louvered ventilation. Even this minimal exchange may permit mold and mildew in damp climates. Monitoring the lighthouse for several months during the initial weatherization period and after the building has been fitted with ventilation louvers and mothballed will provide useful information on the effectiveness of the ventilation solution. Installation of window-mounted passive louver systems is covered in the **Windows** section.

Fire Protection

Fire is a threat to wooden lighthouses. For guidance on this issue, refer to "Fire Prevention and Protection Objectives" under **Related Activities** in Part VI.

Repair

Once a thorough inspection and diagnosis is performed, using the inspection chart on page 4 as a guide, a preservation treatment plan must be developed. The following are general guidelines for preservation repair and maintenance for wooden lighthouses.

Cleaning

The simple act of cleaning painted surfaces can effectively enhance the appearance and extend the life of the coating of historic wooden lighthouse components. In a marine environment a buildup of potentially damaging elements such as salts, bird guano, and in more urban locations, industrial pollutants, can cause premature deterioration of coatings on wooden lighthouses. Simple but effective regular cleaning will greatly extend the life of the wooden components. The following are general guidelines to follow when cleaning historic wooden lighthouse components:

- Clean surfaces only when necessary to remove buildup of salts, guano, mildew and industrial pollutants.
- Clean surfaces with the gentlest method possible, such as low pressure water and mild detergents and natural bristle brushes. Do not use high pressure water blasting. This treatment may damage the wood substrate by breaking through the paint layer and erode the wood or by passing through gaps and saturating interior finishes and exposed bare wood within the wall cavity.
- Do not use a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures.

Failing Paint

Paint is the primary defense used to protect wooden lighthouse building components from the harsh marine environment. Paint applied to exterior wood must withstand yearly extremes of both temperature and humidity. While being merely a temporary coating designed to last between five and eight years, paint is responsible for the exclusion of moisture for the wood substrate. Its role is pivotal because moisture penetration causes most of the wooden component failures in historic lighthouses.

The treatment of failing paint depends on the condition of the paint surface. Paint surface conditions can be grouped according to their relative severity: Class I conditions include minor blemishes or dirt collection and generally require no paint removal; Class II conditions include failure of the layer or layers of paint and generally require limited paint removal; and Class III conditions include substantial or multiple layer failure and generally require total paint removal.

A Guide to Paint Treatment Organized by Surface Condition Classification

WPTC photo

Figure 13. This image shows a Class I paint condition: virtually no deterioration, only some soiling and possible salt buildup resulting from the open-water location of the lighthouse.

Class I: Generally no paint removal—dirt, soot, pollution, chalking, mildew etc., (see Figure 13).

Recommended Treatment: This condition presents a problem only if the surface is to be painted over. If not removed, the surface deposits can be a barrier to proper adhesion and cause peeling. Most surface matter can be loosened by a strong, direct stream of water from the nozzle of a garden-type hose. Stubborn dirt and soot will need to be scrubbed off using a 1/2 cup of household detergent in a gallon of water with a medium soft-bristle brush. (For the removal of mildew add 1 cup of bleach to the non-ammoniated detergent.) The cleaned surface should be thoroughly rinsed and permitted to dry before further inspection to determine if repainting is necessary.

Class II: Generally limited paint removal—crazing, intercoat peeling, solvent blistering, wrinkling (see Figure 14).

Crazing: Fine jagged interconnected breaks in the top layer of paint; results when paint that is several layers thick becomes hard and brittle with age and is no longer able to expand and contract with the wood.

Recommended Treatment: Crazing can be treated by sanding the surface by hand or mechanically, then repainting. Although hairline cracks may tend to show through the new paint, the surface will be protected from moisture penetration.

Intercoat peeling: Can be the result of improper surface preparation before the last repainting. This most often occurs in protected areas such as under covered lighthouse entry ways or under the "shadow" of an overhanging gallery deck. These surfaces do not receive a regular rinsing from rainfall, and salts from airborne pollutants thus accumulate on the surface. If not cleaned off, the new paint coat will not adhere properly and that layer will peel.

Another common cause of intercoat peeling is incompatibility between paint types. For example, if oil paint is applied over latex paint, peeling of the top coat can sometimes result when, upon aging, the oil paint becomes harder and less elastic than the latex paint. If latex paint is applied over old, chalking oil paint, peeling can also occur because the latex paint is unable to penetrate the chalky surface and adhere.

Recommended Treatment: First, where salts or impurities have caused the peeling, the affected area should be washed down thoroughly after scraping, then wiped dry. Finally, the surface should be sanded by hand or mechanically, then repainted. Where peeling was the result of using incompatible paints, the peeling top coat should be scraped and sanded (with an orbital sander only). Application of a high-quality oil-type exterior primer will provide a surface over which *either* an oil or a latex topcoat can be successfully used.

***Solvent blistering*:** The result of a less common application error, caused not by moisture, but by the action of ambient heat on paint solvent or thinners in the paint film. If solvent-rich paint is applied in direct sunlight, the top surface can dry too quickly and, as a result, solvents become trapped beneath the dried paint film. When the solvent vaporizes, it forces its way through the paint film, resulting in surface blisters. This problem occurs more often with dark colored paints because darker colors absorb more heat than lighter ones. To distinguish between solvent blistering and blistering caused by moisture, cut

Figure 14. View of Class II paint condition: this example happens to be on the same lighthouse as the Class I condition shown in the previous image; multiple paint conditions can exist on the same lighthouse. In this example, only spot paint removal and repainting will be required to remedy the condition.

open a blister. If another layer of paint is visible, then solvent blistering is likely the problem whereas if bare wood is revealed, moisture is probably to blame. Solvent blisters are generally small.

Recommended Treatment: Solvent-blistered areas can be scraped, sanded to the next sound layer, then repainted. In order to prevent blistering of painted surfaces, paint should not be applied in direct sunlight.

Wrinkling: An error in application that occurs when the top layer of paint dries before the layer underneath. The top layer of paint actually moves as the paint underneath (a primer, for example) is drying. Specific causes of wrinkling include: (1) applying paint too thick; (2) applying a second coat before the first one dries; (3) inadequate brushing out; and (4) painting in temperatures higher than recommended by the manufacturer.

Recommended Treatment: The wrinkled layer can be removed by scraping followed by sanding (with an orbital sander only) to provide as even a surface as possible, then repainted following manufacturer's application instructions.

Class III: Exterior surface conditions generally requiring total paint removal—peeling, cracking/ alligatoring (see Figure 15).

If surface conditions are such that most of the paint will have to be removed before repainting, leave a small sample of intact paint in an inconspicuous area either by covering the area with a metal plate, or by marking the area and identifying it in some way. (When repainting does take place, the sample should not be painted over). This will enable future investigators to have a record of the building's paint history.

Peeling: Exposing bare wood; most often caused by excess interior or exterior moisture that collects behind the paint film, thus impairing adhesion. Generally beginning as blisters, cracking and peeling occur as moisture causes the wood to swell, breaking the adhesion of the bottom layer.

Recommended Treatment: There is no sense in repainting before dealing with the moisture problems because new paint will simply fail. Therefore, the first step in treating peeling is to locate and remove the source or sources of moisture, not only because moisture will jeopardize the protective coating of paint but because, if left unattended, it can ultimately cause permanent damage to the wood. Excess interior moisture should be removed from the building through installation of exhaust fans and vents. Exterior moisture should be eliminated by correcting the following conditions before repainting: faulty flashing; leaking gutters; defective roof shingles; cracks and holes in siding and trim; deteriorated caulking in joints and seams; and shrubbery growing too close to painted wood. After the moisture problems have

Figure 15. View of Class III paint condition: in this case the cracking, peeling, and alligorating have been caused by excessive paint layer build up.

been solved, the wood must be permitted to dry out thoroughly. The damaged paint can then be scraped off with a putty knife, sanded, primed, and repainted.

Cracking/alligatoring: Advanced stages of crazing. Once the bond between layers has been broken because of intercoat paint failure, exterior moisture is able to penetrate the surface cracks, causing the wood to swell and deeper cracking to take place. This process continues until cracking, which forms parallel to grain, extends to bare wood. Ultimately, the cracking becomes an overall pattern of horizontal and vertical breaks in the paint layers that looks like reptile skin; hence, 'alligatoring'. In advanced stages of cracking and alligatoring, the surfaces will also flake badly.

Recommended Treatment: If cracking and alligatoring are present only in the top layers, they can probably be scraped, sanded to the next sound layer, then repainted. If cracking and/or alligatoring have progressed to bare wood, however, and the paint has begun to flake, it should be totally removed. Methods include scraping or paint removal with the electric heat plate, electric heat gun, or chemical strippers, depending on the particular area involved. Bare wood should be primed within 48 hours, then repainted.

Paint Removal: Selecting the Appropriate/Safest Method

Having presented the "hierarchy" of exterior paint surface conditions—from a mild condition such as mildewing which simply requires cleaning before repainting to serious conditions such as peeling and alligatoring which require total paint removal—one important thought bears repeating: if a paint problem has been identified that warrants either limited or total paint removal, the gentlest method possible for the particular wooden element of the historic lighthouse should be selected from the many available methods.

The treatments recommended take three overriding issues into consideration (1) the continued protection and preservation of the historic exterior woodwork; (2) the retention of the sequence of historic paint layers; and (3) the health and safety of those individuals performing the paint removal. No paint removal method is without its drawbacks, and all recommendations are qualified in varying degrees.

Methods for Removing Paint

WARNING: *Many of these techniques are potentially dangerous and should be carried out only by experienced and qualified workers using proper eye protection and protective clothing, and observing other workplace safety conditions. Before selecting a process, test panels should be prepared to determine the relative effectiveness of various techniques. The cleaning process will most likely expose additional coating defects, cracks, and deterioration that may not have been obvious before.*

After a particular exterior paint surface condition has been identified, the next step in planning for repainting—if paint removal is required—is selecting an appropriate method for such removal. The method or methods selected should be suitable for the specific paint problem as well as the particular wooden element of the lighthouse. Methods for paint removal can be divided into three categories (frequently, however, a combination of the three methods is used).

Each method of paint removal is defined below, then discussed further and specific recommendations made:

Abrasive*:* "Abrading" the painted surface by manual and/or mechanical means such as scraping and sanding. Generally used for surface preparation and limited paint removal.

Thermal: Softening and raising the paint layers by applying heat followed by scraping and sanding. Generally used for total paint removal.

Chemical: Softening of the paint layers with chemical strippers followed by scraping and sanding. Generally used for total paint removal.

Abrasive methods (manual)

If conditions such as crazing, intercoat peeling, solvent blistering, and wrinkling require limited paint removal, scraping and hand sanding should be the first methods employed before using mechanical means. Even in the case of more serious conditions such as peeling (here the damaged paint is weak and already sufficiently loosened from the wood surface), scraping and hand sanding may be all that is needed before repainting.

Recommended abrasive methods (manual):

- ***Putty knife/paint scraper:*** Scraping is usually accomplished with either a putty knife or a paint scraper, or both. Putty knives range in width from one to six inches and have a beveled edge. A putty knife is used in a pushing motion going under the paint and working from an area of loose paint toward the edge where the paint is still firmly adhered and, in effect, "beveling" the remaining layers so that as smooth a transition as possible is made between damaged and undamaged areas. Paint scrapers are commonly available in 1 1/2-, 2 1/2-, and 3 1/2-inch widths and have replaceable blades. In addition, profiled scrapers can be made specifically for use on moldings. As opposed to the putty knife, the paint scraper is used in a pulling motion and works by raking the damaged areas of paint away.

  The obvious goal in using the putty knife or the paint scraper is to selectively remove the affected layer or layers of paint; both of these tools, however, particularly the paint scraper with its hooked edge, must be used with care to properly prepare the surface and to avoid gouging the wood.
- ***Sandpaper/sanding block/sanding sponge:*** After manually removing the damaged layer or layers by scraping, the uneven surface (caused by the almost inevitable removal of varying numbers of paint layers in a given area) will need to be smoothed or 'feathered out' prior to repainting. As stated before, hand sanding, as opposed to harsher mechanical sanding is recommended if the area is relatively limited. A coarse-grit, open-coat flint sandpaper—the least expensive kind—is useful for this purpose because, as the sandpaper clogs with paint, new sheets are used until all layers adhere uniformly. Blocks made of

wood or hard rubber and covered with sandpaper are useful for hand sanding flat surfaces. Sanding sponges—rectangular sponges with an abrasive aggregate on their surfaces that conforms to curves and irregular surfaces—are also available for detail work that requires reaching into grooves. All sanding should follow the grain of the wood.

Abrasive methods (mechanical)

If hand sanding for purposes of surface preparation has not been productive or if the affected area is too large to consider hand sanding by itself, mechanical abrasive methods, i.e., power-operated tools, may be needed; it should be noted, however, that the majority of tools available for paint removal can cause damage to fragile wood and must be used with great care.

Recommended abrasive methods (mechanical):

- ***Orbital sander/random orbit sander:*** Designed as finishing or smoothing tools, not for the removal of multiple layers of paint, these sanders are recommended when limited paint removal is required before repainting. The orbital sander sands in a small diameter circular motion (some models can also be switched to a back-and-forth vibrating action); this tool is particularly effective for "feathering" areas where paint has first been scraped. The abrasive surface varies from about 3 by 7 inches to 4 by 9 inches and sandpaper is attached either by clamps or sliding clips. The random orbit sander does just what its name implies, it sands in a circular motion with a random movement of its axis. This type of sander tends to leave a smoother finish than the orbital sander. The abrasive surface is round and ranges in diameter from 5 to 6 inches and is attached with either a pressure sensitive adhesive backing or a hook and loop fastening system. A majority of commercially available random orbit sanders come equipped with dust pickup connections which is a plus when sanding lead-based paint. For either sander a medium grit, open-coat aluminum oxide sandpaper should be used; fine sandpaper clogs up so quickly that it is ineffective for smoothing paint.

Abrasive methods not to use:

- ***Rotary drill attachments:*** Rotary drill attachments such as the rotary sanding disc and the rotary wire stripper should be avoided. The disc sander—usually a disc of sandpaper about 5 inches in diameter secured to a rubber-based attachment which is in turn connected to an electric drill or other motorized housing—can easily leave visible circular depressions in the wood which are difficult to hide, even with repainting. The rotary wire stripper—clusters of metals wires similarly attached to an electric drill type unit—can actually shred a wooden surface and is used only for removing corrosion and paint from metals.
- ***Belt sander:*** The abrasive surface is a continuous belt of sandpaper that travels at high speeds and consequently offers much less control than the orbital sander. Because of the potential for more damage to the paint or the wood, use of the belt sander can create deep gouges in the wood if not used properly.
- ***Waterblasting*:** Waterblasting above 600 psi to remove paint is not recommended because it can force water into the woodwork rather than cleaning loose paint and grime from the surface; at worst, high pressure waterblasting causes the water to penetrate exterior sheathing and damages interior finishes. The gentlest method involving water uses a detergent solution, a medium soft bristle brush, and a garden hose for purposes of rinsing, and is recommended when cleaning exterior surfaces before repainting.
- ***Sandblasting:*** Finally—and most vehemently "not recommended"—sandblasting painted exterior woodwork will indeed remove paint, but at the same time can scar wooden elements beyond recognition. As with rotary wire strippers, sandblasting erodes the soft porous fibers (spring wood) faster than the hard, dense fibers (summer wood), leaving a pitted surface with ridges and valleys. Sandblasting will also erode projecting areas of carvings and moldings before it removes paint from concave areas. Hence, this abrasive method is the most damaging of all possibilities, even though a contractor might promise that blast pressure can be controlled so that the paint is removed without harming the historic exterior woodwork. For additional information, see NPS *Preservation Briefs 6: Dangers of Abrasive Cleaning to Historic Buildings.*

Thermal methods

Where exterior surface conditions such as peeling, cracking, or alligatoring have been identified that warrant total paint removal, two thermal devices—the electric heat plate and the electric heat gun—have proven to be quite successful for use on different wooden elements of the historic building. One thermal method, the blow torch, is not recommended because it can scorch the wood or even burn the lighthouse down!

Recommended thermal methods:

- ***Electric heat plate:*** The electric heat plate operates between 500 and 800 degrees Fahrenheit (not hot enough to vaporize lead paint), using about 15 amps of power. The plate is held close to the painted exterior surface until the layers of paint begin to soften and blister, then moved to an adjacent location on the wood while the softened paint is scraped off with a putty knife. It should be noted that the heat plate is most successful when the paint is very thick. With practice, the operator can successfully move the heat plate evenly across a flat surface such as wooden siding or a window sill or door in a continuous motion, thus lessening the risk of scorching the wood in an attempt to reheat the edge of the paint sufficiently for effective removal. Since the electric heat plate's coil is "red hot", extreme caution should be taken to avoid igniting clothing or burning the skin. If an extension cord is used, it should be a heavy-duty cord (with 3-prong grounded plugs). A heat plate could overload a circuit or, even worse, cause an electrical fire; therefore, the implement should be used with a single circuit and a fire extinguisher always kept close at hand.
- ***Electric heat gun:*** The electric heat gun (electric hot-air gun) looks like a hand-held hair dryer with a heavy-duty metal case. It has an electrical resistance coil that typically heats to between 500 and 750 degrees Fahrenheit and, again, uses about 15 amps of power, which requires a heavy-duty extension cord. (There are some heat guns that operate at higher temperatures, but they should not be purchased for removing old paint because of the danger of lead paint vapors.) The temperature is controlled by a vent on the side of the heat gun. When the vent is closed, the heat increases. A fan forces a stream of hot air against the painted woodwork, causing a blister to form. At that point, the softened paint can be peeled back with a putty knife.

  Although the heat gun is heavier and more tiring to use than the heat plate, it is particularly effective for removing paint from detail work because the nozzle can be directed at curved and intricate surfaces. It thus is more limited than the heat plate, and is most successful in conjunction with the heat plate. For example, it takes about two to three hours to strip a paneled door with a heat gun, but if used in combination with a heat plate for the large, flat area, the time can usually be cut in half. Although a heat gun seldom scorches wood, it can cause fires (like the blow torch) if aimed at the dusty cavity between the exterior sheathing and siding and interior lath and plaster. A fire may smolder for hours before flames break through to the surface. Therefore, this thermal device is best suited for use on solid decorative elements, such as molding, balusters, and handrails.

Thermal methods not to use:

- ***Blow torch:*** Blow torches, such as hand-held propane or butane torches, were widely used in the past for paint removal because other thermal devices were not available. With this technique, the flame is directed toward the paint until it begins to bubble and loosen from the surface. Then the paint is scraped off with a putty knife. Although this is a relatively fast process, the open flame, at temperatures between 3200 and 3800 degrees Fahrenheit, can not only burn a careless operator and cause severe damage to eyes or skin, it can easily scorch or ignite the wood. The other fire hazard is more insidious. Most frame buildings have an air space between the exterior sheathing and siding and interior lath and plaster. This cavity usually has an accumulation of dust which is also easily ignited by the open flame of a blow torch. Finally, lead-base paints will vaporize at high temperatures, releasing toxic fumes that can be unknowingly inhaled.

Chemical methods

With the availability of effective thermal methods for total paint removal, the need for chemical methods, in the context of preparing historic exterior woodwork for repainting, becomes quite limited. Solvent-base or caustic strippers may, however, play a supplemental role in a number of situations:

- removing paint residue from intricate decorative features, or in cracks or hard-to-reach areas if a heat gun has not been completely effective;
- removing paint on window muntins because heat devices can easily break the glass;
- removing varnish on exterior doors after all layers of paint have been removed by a heat plate/heat gun if the original varnish finish is being restored; or
- removing paint from detachable wooden elements such as exterior shutters, balusters, columns, and doors by dip-stripping when other methods are too laborious.

Recommended chemical methods (use with extreme caution):

Because all chemical paint removers have potential health and safety hazards, only qualified recommendations can be made. Commonly known as ‘paint removers’ or ‘strippers’, both solvent-base or caustic products are commercially available that, when poured, brushed, or sprayed on painted exterior woodwork, soften several layers of paint at a time so that the resulting ‘sludge’—which is nothing less than the sequence of historic paint layers—can be removed with a putty knife. Detachable wood elements such as exterior shutters can also be ‘dip-stripped’.

- ***Solvent-base strippers:*** The formulas tend to vary, but generally consist of combinations of organic solvents such as methylene chloride, isopropanol, toluol, xylol, and methanol; thickeners such as methyl cellulose; and various additives such as paraffin wax used to prevent the volatile solvents from evaporating before they have time to soak through multiple layers of paint. Thus, while some solvent-base strippers are quite thin and therefore unsuitable for use on vertical surfaces, others, called ‘semi-paste’ strippers, are formulated for use on vertical surfaces or the underside of horizontal surfaces.

  Whether liquid or semi-paste, however, there are two important points to stress when using any solvent-base stripper: first, the vapors from the organic chemicals can be highly toxic if inhaled; skin contact is equally dangerous because the solvents can be absorbed; second, many solvent-base strippers are flammable. Even though application out-of-doors may somewhat mitigate health and safety hazards, a respirator with special filters for organic solvents should be worn and, of course, solvent-base strippers should never be used around open flames, lighted cigarettes, or with steel wool around electrical outlets.

  Although appearing to be the simplest for exterior use, a particular type of solvent-base stripper should be mentioned here because it can actually cause more problems. Known as ‘water-rinsable’, such products have a high proportion of methylene chloride together with emulsifiers. Although the dissolved paint can be rinsed off with water with a minimum of scraping, this ultimately creates more of a problem in cleaning up and properly disposing of the sludge. In addition, these strippers can leave a gummy residue on the wood that requires removal with solvents. Finally, water-rinsable strippers tend to raise the grain of the wood more than regular strippers.

  On balance, then, the regular strippers would seem to work just as well for exterior purposes and are perhaps even better from the standpoint of proper lead sludge disposal because they must be hand scraped as opposed to rinsed off. (A coffee can with a wire stretched across the top is one effective way to collect the sludge; when the putty knife is run across the wire, the sludge simply falls into the can. Then, when the can is filled, the wire is removed, the can capped, and the lead paint sludge disposed of according to local health regulations.)

- ***Caustic strippers:*** Until the advent of solvent-base strippers, caustic strippers were used exclusively when a chemical method was deemed appropriate for total paint removal before repainting or refinishing. Now, commercially prepared caustic solutions are more difficult to find in hardware and paint stores for home-owner use with the exception of lye (caustic soda) because solvent-base strippers packaged in small quantities tend to dominate the market.

Most commercial dip stripping companies, however, continue to use variations of the caustic bath process because it is still the cheapest method available for removing paint. Generally, dip stripping should be left to professional companies because caustic solutions can dissolve skin and permanently damage eyes as well as present serious disposal problems in large quantities.

If exterior shutters or other detachable elements are being sent out for stripping in a caustic solution, it is wise to see samples of the company's finished work. While some companies do a first-rate job, others can leave a residue of paint in carvings and grooves. Wooden elements may also be soaked too long so that the wood grain is raised and roughened, requiring extensive hand sanding later. In addition, these companies should give assurances that caustic paint removers will be neutralized with a mild acid solution or at least thoroughly rinsed with water after dipping (a caustic residue makes the wood feel slippery). If this is not done, the lye residue will cause new paint to fail.

Painting

Assuming that the exterior wood has been painted with oil paint many times in the past and the existing top coat is therefore also an oil paint, a top coat of high quality oil paint should be applied when repainting *Class I* and *Class II* paint surface conditions. There are two reasons for recommending oil rather than latex paints: 1) a coat of latex paint applied directly over old oil paint is more apt to fail because of different rates of shrinkage; 2) oil paints withstand the harsh conditions of a marine environment better than latex.

- If Class III conditions have necessitated total paint removal, an oil-based primer/top coat system should be applied to ensure the maximum protection of the wood. For the best results the primer and top coat should be manufactured by the same company. Note also that primers were never intended to withstand the effects of weathering; therefore, the top coat should be applied as soon as possible after the primer has dried.
- To ensure that the maximum life expectancy of the paint is achieved, follow the manufacturer's specifications and guidelines that are included with the product (either directly on the label or as included literature).
- All paint on wood surfaces should be applied with good quality natural bristle brushes. All brushing should be done with the grain of the wood. Brush painting ensures the best coverage and in turn the most durable finish.

Repair of Damaged/Deteriorated Wooden Components

Exterior wood trim on historic lighthouses often performs the dual function of weather protection and decoration. Moldings, siding, and trim not only create visual interest with highlights and shadows, but also have practical value. In addition to covering joints and protecting the wood end grain, they direct rainwater from one component to the next and eventually to the ground.

General Guidelines for Wood Repair

Identify, retain, and preserve wood features that are important in defining the overall historic character of the building, such as siding, cornices, brackets, window architraves, and doorway pediments, and their paints, finishes, and colors.

- During the inspection of the historic wooden lighthouse, identify character-defining features of the wooden components such as the species of wood, grain pattern, dimensions, millwork, shaping, joining, and finishing techniques, and means of fastening.
- Historically, the wood species was chosen for its inherent qualities. Oak, fir, and pine, all common building lumber, exhibit varying strength and resistance to decay. When

choosing a wood species for repair or replacement, these factors should be considered.

- The use of lumber treated to resist decay is only appropriate for hidden structural components.
- Determine if a wood element functions as a structural, decorative, or finish material, This information will dictate the priority of treatment, e.g., a structural beam or column will take precedence over applied trim that serves no other function than decoration.
- Do not remove or radically change wood features that are important in defining the overall historic character of the building, or provide weather protection for the lighthouse.
- Do not radically change the type of finish or its color or accent scheme so that the historic character of the exterior is diminished or the daymark characteristics of the lighthouse are altered.
- Do not remove all paint layers without retaining samples for analysis and documentation. In the case of a lighthouse where total paint removal is required, if possible leave a patch of undisturbed paint in a protected area such as on a wall under a covered entry or behind a shutter. The location of the sample should be identified in the project record and kept in the lighthouse maintenance file.
- For all exterior wood repairs galvanized or stainless steel fasteners (nails, screws, and bolts) must be used in order to prevent the premature failure of the repair by fasteners that rusted and failed. When used, finish nails should be countersunk and the depression filled with wood filler applied over the nailheads.
- Do not replace an entire wood feature, such as a cornice or wall, when repair of the wood and limited replacement of deteriorated or missing parts are appropriate.
- Damaged or missing trim elements that maintain the exterior weathertight envelope must be repaired as soon as possible.
- For the replacement part, do not use substitute material that does not have the appearance of the surviving parts of the wood feature or that is physically or chemically incompatible.
- Do not remove an entire wood feature that is beyond repair and not replace it, or replace it with a new feature that does not have the same appearance.
- Do not replace milled lumber with plywood. Plywood is both historically inappropriate and visually distinct from historic wood.

As part of an effective treatment program, inspect wood surfaces and structural elements regularly for signs of moisture retention and insect or fungal attack. Peeling paint, spongy wood, discoloration, staining, and the presence of fungi are clear indicators of wood deterioration caused by elevated moisture content. (See the **Windows** section for inspection techniques for damaged and deteriorated wood.) Insect damage generally occurs on the interior of a wood member and may be hidden until the structural integrity is severely compromised. Sills and wood joints or members bearing on masonry are particularly susceptible to rot, because they are frequently subjected to moisture.

Wood structures are most commonly weakened when the original cross section of a structural member is reduced by portions cut out by alterations, fire, insect damage, or fungal rot. Rot on the original member must be removed before installing new material.

Deteriorated portions of wood can be effectively repaired using like-kind splices. Splicing of a wood member is required when a portion of the wood component, i.e., handrail, has been damaged or has deteriorated and only that portion needs to be removed and a new section attached in its place. The replacement member should match the existing members in species and grain orientation and in any existing shape or profile. The new member can even be made from matching salvaged stock. All deteriorated material should removed and the end where the replacement member will be attached should be cut on a diagonal to increase the gluing surface area.

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Figure 18. The wooden structural member that this bracket is attached to is extensively deteriorated. This condition is a prime example of deterioration that can be repaired by cutting back the rotted wood to a sound substrate, then fitting the void created with a wooden 'dutchman' or infill that matches as closely as possible the grain orientation and wood species as the existing member. Once the dutchman has been glued, and if needed, doweled in place, then the affected area should be properly primed and painted. This technique is affordable and incurs only minimal damage to the existing historic materials.

Then drill aligned holes in both members for reinforcing dowels.

A 'dutchman' is a fitted patch in a wood member that only has localized deterioration. To fit a dutchman, first probe the deteriorated area to determine size and the approximate depth of the deterioration. Second, cut a wood patch or 'dutchman' with its grain aligned with the existing members. The dutchman can be rectangular or diamond-shaped; a diamond shape is a little more difficult to fit but will provide more gluing surface and blend with the grain better when the wood is finished with varnish instead of paint. Be sure the dutchman is large enough to cover the affected area and thicker than the deterioration is deep. Slightly bevel all of the edges of the dutchman so that the widest face is the top. This will ensure a tight, cork-like fit. Next, trace the outline of the dutchman's narrowest face on the existing member over the deterioration. Using the outline as a guide, carefully remove all of the deteriorated wood with a chisel. Test fit the dutchman and trim the hole until the dutchman bottoms out and fills the affected area entirely; the dutchman should be slightly proud of the existing material. Glue and clamp the dutchman in place. Once the glue has cured, use a chisel or hand plane to make the dutchman flush with the surrounding material. Hand sanding can be used for the final leveling of the two surfaces.

Consolidation and Epoxy Repairs

Deteriorated features can be repaired using consolidation and epoxy techniques. This type of treatment is irreversible and should be used if other treatments are ineffective. (For more information on consolidants and epoxy treatments refer to the **Windows** section.)

Flashing and Joint Repairs

Maintain successful existing details of joints and flashing that keep water out of wood assemblies, and consider historic detail reconstruction before caulking. Replace missing wood features, especially those on the exterior, in a timely manner. Exterior wood components are usually designed, joined, and flashed to prevent water from penetrating joints. One missing element can compromise the entire system. The high-quality caulks that are available today can be used for short-term temporary repairs. Caulk, however, should not be regarded as a long-term repair for a condition where the original flashing or trim detail is missing or damaged.

When vertical elements are repaired, cut vertical replacement pieces on a diagonal to direct water from the joint. Horizontal joints tend to collect water. To minimize cracking and splitting, use predrilling and screws in old brittle wood rather than nails. Replace wood features using the same joining techniques as found in the original feature, e.g., if two members are joined with a mortise and tenon joint, the repair should be joined using a mortise and tenon joint.

Structural Stabilization

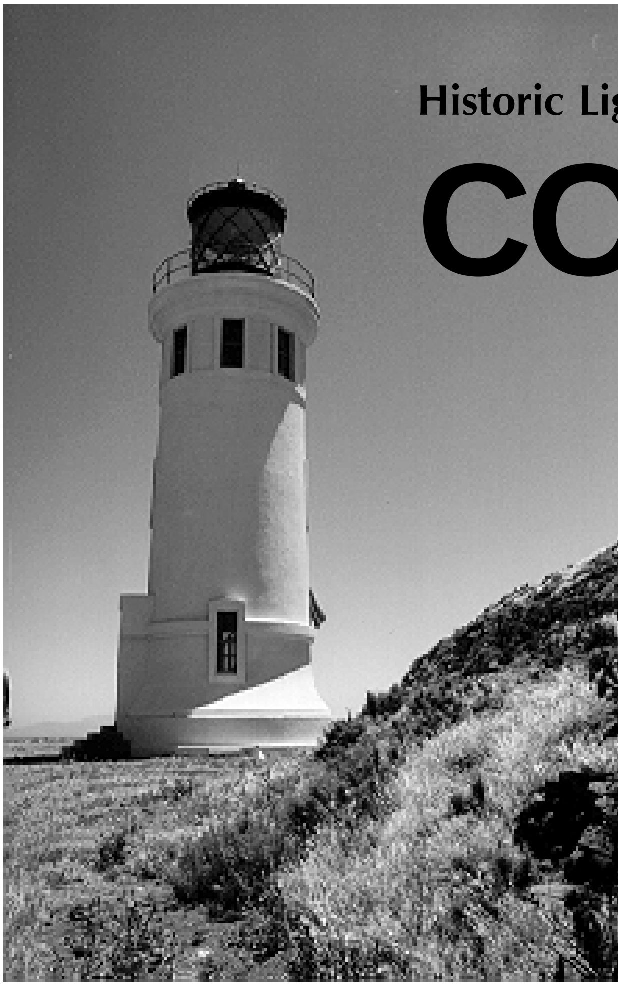
Wood structural components that have experienced extensive deterioration will require stabilization to prevent failure and possible collapse of the lighthouse. Effective methods of stabilization include: installation of intermediary bracing and shoring that supports compromised members, and 'sistering' of wood or steel members to compromised members to help carry the load. All temporary treatments should be reversible and not incur further damage to the lighthouse. Before a permanent structural stabilization is performed, an engineer or historical architect should be consulted.

Limited Replacement In Kind

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the limited replacement in kind of extensively deteriorated or missing parts of features when there are surviving prototypes (for example, wooden cornices, door pediments, window architraves, and wall coverings i.e., shingles or siding). The replacement material needs to match the old both physically and visually, i.e., 8- by 18-inch cedar shingles with 8- by 18-inch cedar shingles, etc. With the exception of hidden structural reinforcement and new mechanical system components, substitute materials are not appropriate in the preservation treatment**.** It is important that all new material be identified and properly documented for future research.

If prominent features are missing, then a rehabilitation or restoration treatment may be more appropriate.

WPTC photo



Historic Lighthouse Preservation:

CONCRETE

Figure 1. Anacapa Island Lighthouse is a reinforced concrete lighthouse located on a highly exposed island off the California coast. Concrete was chosen because of its ability to withstand the high winds, harsh climate, and seismic activity of this exposed location.

Concrete[1] is the fourth most common lighthouse construction material. The 1908 Point Arena Lighthouse, the first reinforced concrete lighthouse in the United States was constructed in response to the search for an earthquake-proof construction material. (The Point Arena Lighthouse is located within 10 miles of the San Andreas Fault.) The Point Arena Lighthouse, however, was not the first lighthouse to use concrete in its construction. Caisson-style lighthouses typically used concrete as fill and ballast to help sink the caisson, however, this type of concrete was not reinforced.

Concrete features (such as cast moldings and brackets, poured in-place foundations) as well as concrete surfaces (modeling and tooling, texture and color) are usually important in defining the historic character of a lighthouse and should be retained during any treatment. While concrete is among the most durable of historic building materials, it is still susceptible to damage by improper maintenance or repair techniques and by harsh or abrasive cleaning methods. When performing any treatments on a concrete lighthouse, use the gentlest means possible.

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[1]'Concrete' is a name applied to any of a number of compositions consisting of sand, gravel, crushed stone, or other coarse material, bound together with various kinds of cementitious materials, such as lime or cements. When water is added, the mix undergoes a chemical reaction and hardens. Traditionally, concrete is not referred to as masonry.

Figure 2. View of the Alcatraz Island Lighthouse. Reinforced concrete was chosen for this lighthouse location for its ability to withstand earthquakes.

Figure 3. For the construction of this caisson-style lighthouse, unreinforced concrete was used as ballast to sink the cast-iron caisson foundation deep into the mud on the bottom of the Chesapeake Bay in Maryland.

Historical Overview

The Romans found that the mixture of lime putty with pozzolana, a fine volcanic ash, would harden under water. The result was possibly the first hydraulic cement. It became a major feature of Roman building practice, and was used in many buildings and engineering projects such as bridges and aqueducts. Concrete technology was kept alive during the Middle Ages in Spain and Africa, with the Spanish introducing a form of concrete to the New World in the first decades of the 16th century. It was used by both the Spanish and English in coastal areas stretching from Florida to South Carolina. Called 'tapia', or 'tabby', the substance was a creamy-white, monolithic masonry material composed of lime, sand, and an aggregate of shells, gravel, or stone mixed with water.

Reinforced concrete in the United States dates from 1860, when S. T. Fowler obtained a patent for a reinforced concrete wall. In the early 1870s William E. Ward built his own house in Port Chester, New York, using concrete reinforced with iron rods for all structural elements. Despite these developments, such construction remained a novelty until after 1880, when innovations introduced by Ernest L. Ransome made reinforced concrete more practical. The invention of the horizontal rotary kiln allowed production of a cheaper, more uniform and reliable cement, and led to the greatly increased acceptance of concrete after 1900. These developments in concrete technology and manufacture ultimately led to the use of reinforced concrete in the construction of lighthouses.

As mentioned in the introduction, the first reinforced concrete lighthouse was constructed at Point Arena, California in 1908 (see Figure 5). The construction of this lighthouse established a trend of using reinforced concrete for lighthouses on the

West Coast and Alaska. This trend continued into the 1920s and 1930s. The construction of reinforced concrete lighthouses was not limited to the West Coast and Alaska; concrete lighthouses were constructed on the Eastern Seaboard as well. The last one, St. John's River Lighthouse, was constructed in 1954 in Mayport, Florida (Figure 5). The reason for concrete's popularity in lighthouse construction was that it was durable, was cheap compared to traditional masonry construction, and required minimal initial maintenance.

Types of Concrete

- ***Unreinforced concrete*** is a composite material containing aggregates (sand, gravel, crushed shell, or rock) held together by a cement combined with water to form a paste. It gets its name from the fact that it does not have any iron or steel reinforcing bars. It was the earliest form of concrete. The ingredients become a plastic mass that hardens as the concrete hydrates, or 'cures'. This form of concrete is typically used in caisson-style lighthouse construction as ballast to weight the caisson foundation (see Figure 3). Unreinforced concrete, however, is relatively weak, and since the turn of the century has largely been replaced by reinforced concrete.
- ***Reinforced concrete*** is concrete strengthened by the inclusion of metal bars, which increase the tensile strength of concrete. Both unreinforced and reinforced concrete can be either cast in place or precast.
- ***Cast-in-place*** concrete is poured onsite into a previously erected form that is removed after the concrete has set. Lighthouses are typically constructed using cast-in-place construction methods. The advantage to this method of construction is that once the concrete has cured, the lighthouse is a monolithic structure.
- ***Precast concrete*** is molded offsite into building components. This method of construction is seldom used for lighthouses.

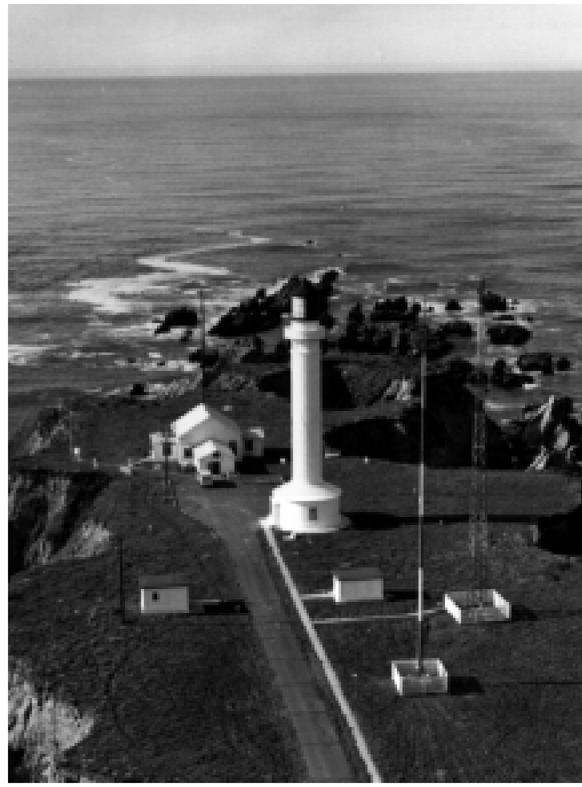
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Figure 4. The first reinforced concrete lighthouse, Point Arena Light Station in California.


WPTC photo

Figure 5. St. John's River Lighthouse, Mayport, Florida, was constructed of reinforced concrete for its economy and low maintenance.

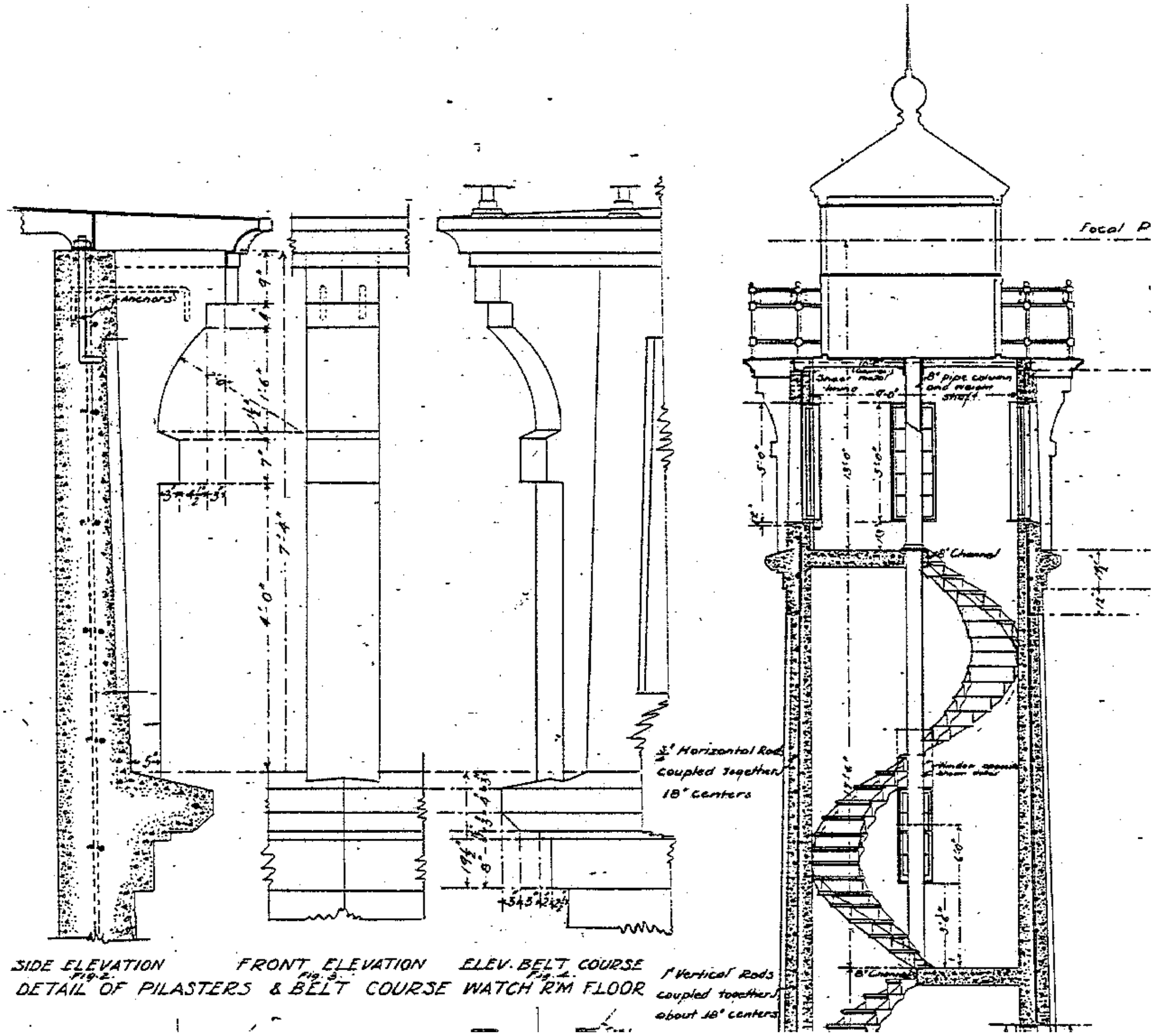

Figure 6. Image showing the placement of reinforcing bars in concrete lighthouse construction. (Image courtesy of CEU Oakland)

Causes of Concrete Deterioration

Deterioration of concrete lighthouses can be caused by environmental factors, inferior materials, poor workmanship, inherent structural design defects, and inadequate maintenance.

- ***Environmental factors*** are a principal cause of concrete deterioration. Concrete absorbs moisture readily if not coated; this is particularly troublesome in regions of recurrent freeze-thaw cycles. Freezing water produces expansive pressure in the cement paste or in nondurable aggregates. Carbon dioxide, another atmospheric component, can cause the concrete to deteriorate by reacting with the cement paste at the surface.
- ***Materials and workmanship*** in the construction of early concrete buildings are potential sources of problems. For example, aggregates used in early concrete, such as cinders from burned coal and certain crushed brick, absorb water and produce a weak and porous concrete. Alkali-aggregate reactions within the concrete can result in cracking and white surface staining. Aggregates were not always properly graded by size to ensure an even distribution of elements from small to large. The use of aggregates with similarly sized particles normally produced a poorly consolidated and therefore weaker concrete.

Early lighthouse builders sometimes inadvertently compromised concrete by using seawater or beach sand in the mix. A common practice, until recently, was to add salt to strengthen concrete or to lower the freezing point during cold-weather construction. These practices cause problems over the long term.

In addition, early concrete was not vibrated when poured into forms as it is today. More often it was tamped or rodded for consolidation; on floor slabs, it was often rolled with increasingly heavier rollers filled with water. These practices tended to leave voids (areas of no concrete) at congested areas, such as at reinforcing bars at column heads and other critical structural locations. Areas of connecting voids seen when concrete forms are removed are known as 'honeycombs' and can reduce the protective cover over the reinforcing bars.

Other problems caused by poor workmanship are not unknown in later concrete work. If the first layer of concrete is allowed to harden before the next one is poured next to or on top of it, joints can form at the interface of the layers. In some cases, these 'cold joints' visibly detract from the architecture, but are otherwise harmless. In other cases, 'cold joints' can permit water to infiltrate, and subsequent freeze-thaw action can cause the joints to move. Dirt packed in the joints allows weeds to grow, further opening paths for water to enter. Inadequate curing can also lead to problems. If moisture leaves newly poured concrete too rapidly because of low humidity, excessive exposure to sun or wind, or use of too porous a substrate, the concrete will develop shrinkage cracks and will not reach its full potential strength.

- ***Structural design defects*** in historic concrete structures can be an important cause of deterioration. For example, the amount of protective concrete cover around reinforcing bars was often insufficient. Another design problem in early concrete buildings is related to the absence of standards for expansion-contraction joints to prevent stresses caused by thermal movements, which may result in cracking.
- ***Improper maintenance*** of historic lighthouses can cause long-term deterioration of concrete. Water is a principal source of damage to historic concrete (as to almost every other material), and prolonged exposure to it can cause serious problems. Unrepaired roof and plumbing leaks, leaks through exterior cladding, and unchecked absorption of water from damp earth are potential problems. Deferred repair of cracks allowing water penetration and freeze-thaw attacks can even cause a structure to collapse. In some cases the application of waterproof surface coatings can aggravate moisture-related problems by trapping water vapor within the underlying material.

Major Signs of Concrete Deterioration

- ***Cracking*** occurs over time in virtually all concrete. Cracks vary in depth, width, direction, pattern, location, and cause. Cracks can be either active or dormant (inactive). Active cracks widen, deepen, or migrate through the concrete. Dormant cracks remain unchanged. Some dormant cracks, such as those caused by shrinkage during the curing process, pose no danger, but if left unrepaired, they can provide convenient channels for moisture penetration, which normally causes further damage.

  Structural cracks can result from temporary or continued overloads, uneven foundation settling, or original design inadequacies. Structural cracks are active if the overload is continued or if settlement is ongoing; they are dormant if the temporary overloads have been removed, or if differential settlement has stabilized. Thermally-induced cracks result from stresses produced by temperature changes. They frequently occur at the ends or corners of older concrete structures built without expansion joints capable of relieving such stresses. Random surface cracks (also called 'map' cracks because of their resemblance to the lines on a road map) that deepen over time and exude a white gel that hardens on the surface are caused by an adverse reaction between the alkalis in a cement and some aggregates.

Since superficial repairs that do not eliminate underlying causes will only tend to aggravate problems, professional consultation is recommended in almost every instance where noticeable cracking occurs.

- ***Spalling*** is the loss of surface material in patches of varying size. It occurs when reinforcing bars corrode, thus creating high stresses within the concrete. As a result, chunks of concrete pop off from the surface. Similar damage can occur when water absorbed by porous aggregates freezes. Vapor-proof paints or sealants, which trap moisture beneath the surface of the impermeable barrier, can also cause spalling. Spalling may also result from the improper consolidation of concrete during construction. In this case, water-rich cement paste rises to the surface (a condition known as laitance). The surface weakness encourages scaling, which is spalling in thin layers.

- ***Deflection*** is the bending or sagging of concrete beams, columns, joists, or slabs, and can seriously affect both the strength and structural soundness of concrete. It can be produced by overloading, by corrosion, by inadequate construction techniques (use of low strength concrete or undersized reinforcing bars, for example), or by concrete creep (long-term shrinkage). Corrosion may cause deflection by weakening and ultimately destroying the bond between the rebar and the concrete, and finally by destroying the reinforcing bars themselves. Deflection of this type is preceded by significant cracking at the bottom of the beams or at column supports. Deflection in a structure without widespread cracking, sparing, or corrosion is frequently caused by concrete creep.

- ***Stains*** can be produced by alkali-aggregate reaction, which forms a white gel exuding through cracks and hardening as a white stain on the surface. Efflorescence is a white, powdery stain produced by the leaching of lime from Portland cement, or by the pre-World War II practice of adding lime to whiten the concrete. Discoloration can also result from metals inserted into the concrete, or from corrosion products dripping onto the surface.

- ***Erosion*** is the weathering of the concrete surface by wind, rain, snow, and salt air or spray. Erosion can also be caused by the mechanical action of water channeled over concrete, by the lack of drip grooves in belt courses and sills, and by inadequate drainage.

- ***Corrosion,*** the rusting of reinforcing bars in concrete, can be a most serious problem. Normally, embedded reinforcing bars are protected against corrosion by being buried within the mass of the concrete and by the high alkalinity of the concrete itself. This protection, however, can be destroyed in two ways. First, by carbonation, which occurs when carbon dioxide in the air reacts chemically with cement paste at the surface and reduces the alkalinity of the concrete. Second, chloride ions from salts combine with moisture to produce an electrolyte that effectively corrodes the reinforcing bars. Chlorides may come from seawater additives in the original mix, or from prolonged contact with salt spray, or de-icing salts. Regardless of the cause, corrosion of reinforcing bars produces rust, which occupies significantly more space than the original metal, and causes expansive forces within the concrete. Cracking and spalling are frequent results. In addition, the load-carrying capacity of the structure can be diminished by the loss of concrete, by the loss of bond between reinforcing bars and concrete, and by the decrease in thickness of the reinforcing bars themselves. Rust stains on the surface of the concrete are an indication that internal corrosion is taking place.

Inspecting for Concrete Problems

In order to develop an effective treatment plan for concrete problems, an in-depth inspection must be made of the lighthouse and its immediate surroundings. The following chart is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Concrete Lighthouses	
THE SITE	
Look For:	*Possible Problems:*
Environment	
Typical climatic conditions, including average temperatures, wind speeds and directions, humidity levels, average snow accumulation, ice, wave action, salt spray, and blown sand	Severe conditions can lead to concrete deterioration, including cracking, spalling, surface erosion, and efflorescence. Concrete lighthouse features can be broken or damaged by the weight of excessive ice buildup or by the impact of violent wave action or wave-carried debris.
Number of freeze-thaw cycles	Severe cycles can produce damage from frost action if moisture is trapped in concrete walls or there is a lack of total structure ventilation. Daily freeze-thaw cycles may also cause excessive condensation buildup within the tower, promoting fungal growth and rot as well as causing iron components such as stairs, landings, and hatches to rust and deteriorate.
Location near sea	Salt in the air can lead to efflorescence forming on the concrete.
Acid rain in the region or from nearby industry or from automobile exhaust	Acid rain can cause damage to concrete.
Location in the flood plain of a river, lake, or sea	Prolonged immersion in floodwater can bring damaging moisture to foundations and walls.
Exposed or sheltered locations/elements of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration. Portions of the lighthouse that do not receive sunlight are susceptible to mildew and other forms of biological attack.
Terrain	
Soil type—clay, sand, rock	The type of soil influences water drainage around the structure. Excessive water in the soil can cause rising damp, leading to structural problems.
Slope away from lighthouse on all sides	If no slope exists, puddles will form at the base of the lighthouse during heavy rains. This may lead to localized ground saturation and to water penetration. Localized ground saturation may cause soil around the lighthouse to shift, possibly resulting in uneven settlement.

Look for:	*Possible Problems:*
Earth covering part of a concrete wall or foundation	Moisture accumulation or penetration is possible.
Asphalt or other impervious paving touching the lighthouse foundation (if exposed) or walls	Detrimental water accumulation and rain splash-back onto the walls can result. Splash-back can saturate the concrete, which may cause premature failure of exterior coatings (if present).
Trees and Vegetation	
Species of trees within 50 feet of lighthouse	Elms and some poplars dry up clay soil, possibly leading to foundation failure.
Branches rubbing against a wall or roof	Branches may abrade surfaces.
Ivy or creepers on walls	Leaves prevent proper drying of the concrete surface.
THE LIGHTHOUSE	
Exterior Walls	
General state of maintenance and repair	A well maintained lighthouse should require fewer major repairs.
Evidence of previous fire or flooding	Such damage may have weakened structure members or caused excessive moisture infiltration.
Construction method—solid or cavity wall	Knowing how a tower wall is constructed will help in analyzing problems and selecting appropriate treatments.
Embedded iron (steel) anchors, structural members, reinforcement bars, etc.	As iron (steel) rusts, it expands; this expansion can damage the surrounding concrete.
Evidence that parts of the lighthouse were constructed at different times or of different materials	Similar problems with various parts may need different treatments because of different materials.
Attached antennas, range finders, auxiliary or replacement lights, etc.	Heavy devices which are cantilevered off the side of the tower wall may cause eccentric loading. If this load is improperly distributed, severe cracking and possible localized failure may result.
Cracks	Cracks indicate that movement has occurred within the wall. Small cracks may be patched; large cracks may require reconstruction of the affected area.
Enlarging cracks	Active cracks indicate a continuing problem. The cause must be dealt with before the crack itself is repaired.
Spalling of concrete surface	Spalling indicates that the internal reinforcing bars have corroded, causing high stresses within the concrete. As a result, the concrete ‘pops’ off in chunks, exposing the corroded reinforcing bar.

Look for:	*Possible Problems:*
Windows and Doors	
Sills sloped to shed water; drips under sills to prevent water from running back underneath; caulking	If any of these is inadequate, water can penetrate into the lighthouse wall.
Sealed window and door frames	If caulking is missing or deteriorated around window and door frames, moisture can penetrate into the wall cavity and cause deterioration of the window or door frame, as well as of the concrete.
Foundation	
Uneven settlement	This may cause the leaning tower effect and possibly result in collapse of the lighthouse.
Composition of foundation walls	Stone or brick are more likely than concrete to allow water to infiltrate.
Undermining of the foundation caused by erosion	Undermining may cause a catastrophic failure of the foundation and may result in total lighthouse collapse. The remedy is to address the cause of the erosion. Minor undermining should be back-filled with a stable, graded fill material containing a range of aggregate sizes for good compaction. For major undermining a structural engineer should be consulted.
Interior	
Cracked plaster, signs of patching, stairs and landings askew	These may be signs of lighthouse settlement.
Damp walls, mold or mildew stains on walls, efflorescence, 'bubbling' or blistering plaster or painted finish, rotting wood	These indicate water infiltration or severe condensation or moisture buildup within the tower.
Concrete Components	
Materials	
Composition, including secondary materials; characteristics—color and color variation; texture—smooth or patterned surfaces	Types of materials indicate the susceptibility or resistance to damage and should be matched if the concrete component is repaired or replaced.
Areas of delicate moldings or fine castings	These sections may need special attention or protection during rehabilitation.
Missing or spalled patches of concrete	Missing material may allow water penetration, as well as indicate corrosion of the concrete reinforcement.
Evidence of previous patches	Patches are signs of past damage or deterioration. If the repair was not made properly, the patch may cover a potential source of future deterioration. Any patched areas should be monitored and inspected regularly for signs of deterioration.

Look for:	*Possible Problems:*
Dirt or stains	Surface stains usually cause few problems other than being unpleasant to look at. Streaking on the surface of the lighthouse tower, however, may be an indicator of deteriorating materials that are not readily visible, such as rust streaks from embedded iron anchors or reinforcement rods, etc.
Moisture	
Water penetration through joints between concrete and other lighthouse components, through expansion joints or, rarely, through the concrete itself	Moisture can lead to deterioration of the concrete and other parts of the structure.
Staining or white deposits (efflorescence), mold and mildew stains on walls	White deposits are evidence of excessive dampness.
Location and type of salt deposits on surface; standing water	Deposits can indicate a source of dampness, such as rainwater or ground water, inside the lighthouse materials.
Coatings	
Applied coating type: stucco, lime mortar wash, or paint	Applied stucco is common lighthouse coating; the surface should be inspected for cracks that could allow water infiltration. Lime mortar wash or whitewash is another common concrete lighthouse coating. This coating is considered a sacrificial coating. The lime mortar wash protects the lighthouse by wearing away over time. This coating is meant to be reapplied periodically like paint.
Paint; type of paint	A paint that does not breathe can trap moisture within the concrete and cause the surface to spall.
Blistering, flaking and peeling paint, failure of plaster or stucco and interior painted finishes	These conditions indicate the paint does not breathe.
Waterproof or water-repellent coating	Such coatings often trap moisture within the concrete.

PRESERVATION TREATMENTS

WARNING: Many of the maintenance and repair techniques described in this text, particularly those relating to cleaning and painting, are potentially dangerous and should be carried out only by experienced and qualified workmen using protective equipment suitable to the task. It may be necessary to involve a USCG engineer or architect, preservation architect, or building conservator familiar with lighthouse preservation to assess the condition of the concrete and prepare contract documents for its treatment.

Many of the maintenance and repair techniques described in this text, if not properly performed, can cause potentially irreversible damage to the character-defining features and historic fabric of the concrete lighthouse. Therefore, if the tasks to be performed are beyond the skills of onsite personnel, they should be carried out by experienced and qualified workmen. In the **Beyond Basic Preservation** section of this Handbook, examples of treatments that are considered rehabilitation and restoration are illustrated and discussed.

Protection and Stabilization (Mothballing)

Despite their inherent durability, concrete lighthouses are still susceptible to accelerated decay. A historic concrete lighthouse that receives only minimal routine maintenance is highly vulnerable to decay if it is not protected and stabilized properly. A thorough inspection and diagnosis should be performed using the inspection chart in the preceding section as a guide; the results of which can then be used to develop a protection and stabilization plan. The following recommended protection and stabilization guidelines for vacant historic concrete lighthouses are minimum treatment requirements to prevent any further damage from occurring.

Weatherization

To protect a historic concrete lighthouse, the exterior envelope should be completely weathertight. When moisture penetrates into concrete walls and foundations, it can be exceedingly detrimental to the integrity of the concrete. Moisture in a wall or foundation may cause various types of damage: reinforcement bars may rust, expansion caused by freezing may crack surrounding concrete, efflorescence (the leaching of salts out of the concrete) may appear, adjacent wood elements may rot, adjacent metal elements may rust or corrode, or fungal growth may occur.

To prevent moisture penetration, be sure the following moisture infiltration points are weathertight or functioning properly:

- ***Lantern glass:*** Lantern glass, frames, and roofs must be weathertight before mothballing. Refer to the **Lantern** section for more information concerning the weatherproofing of the lantern components. (See Figures 7 and 8 in the **Masonry** section which illustrate a broken glass panel and a temporary repair using a metal plate and caulking.)

  A temporary patch repair will prevent water from entering the lantern and therefore help avoid incurring further damage. This fix should be considered only as an interim treatment until the glass can be replaced. For more on lantern glass replacement refer to **Lantern** section.

- ***Built-in gutter systems:*** All rainwater gutter systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. All holes and non-functioning gutter system components should be repaired. For more information refer to the discussion on roofing in the **Lantern** section.

- ***Gallery decks:*** In most concrete lighthouses gallery decks are cast iron, stone, or concrete. These decks are generally laid directly on top of the concrete wall structure. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior of the lighthouse or saturate the concrete wall. See Figure 7 for signs that a gallery deck is failing. Refer to the **Lantern** section for more information concerning the weatherproofing of gallery decks.
- ***Door and window frames:*** The joints along the perimeter of doors and windows where a wood or metal frame is fitted into a concrete opening should be caulked to prevent moisture from entering the walls. See the **Windows** section for the proper caulk for this application.
- ***Protective coatings:*** Lighthouses were often painted as a protective measure and for identification as a daymark. As part of a protective treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color.


WPTC photo

Figure 7. The concrete gallery deck on this concrete lighthouse has been covered with a rubber membrane. This covering should be checked regularly for leaks.


WPTC photo

Figure 8. Close-up view of a glass-block window in a concrete lighthouse. The joint where the glass block meets the concrete wall should be caulked to prevent moisture infiltration.

Ultimately, the entire lighthouse should have all loose and flaking paint removed and a new coating applied according to the manufacturer's specifications. If the overall condition of the coating system is sound and there are only a few bare spots, however, the lighthouse can be spot-painted to provide a weatherproof coating. Either of these actions will result in a coating system that will require minimal interim maintenance. For more information refer to the discussion on repainting in the following repair section.

If the lighthouse was historically protected by a stucco coating, the surface should be checked for loose or delaminating patches. Any sections that are loose could trap moisture and cause premature deterioration of the concrete structure. The repair of damaged stucco coatings is covered in the following section on concrete repair.

- ***Open cracks in walls:*** Cracks in exterior concrete walls indicate that movement has

WPTC photo

Figure 9. Patches of spalled concrete: familiar with lighthouse preservation the one pictured here should be repaired to protect the underlying concrete structure.

occurred, either movement caused by shrinkage (in the case of stucco) or by settlement or mechanical impact. Cracks should be monitored to determine if movement is still occurring and structural stabilization is necessary before the crack is filled. Refer to the following repair section for more information concerning wall repair.

Stabilization

If funds are insufficient to make repairs, structural stabilization should be performed as a less expensive temporary alternative. Temporary blocking in of window and door openings and installation of interior or exterior shoring or bracing are all stabilization methods. The stabilization treatment utilized should not permanently damage historic character-defining features and should be easily reversible so that when the budget allows, the structure can be properly repaired. Refer to the following

WPTC photo

Figure 10. Cracks like the one here, extending down from the belt course of this concrete lighthouse, should be monitored for movement before any patching is performed.

repair section for more information on structural concrete repairs.

Ventilation

Much like masonry lighthouses, concrete lighthouses are difficult to ventilate without resorting to extensive louvering and/or mechanical exhaust fan systems. During the summer months concrete lighthouses will need to have maximum air exchange to eliminate damaging condensation on the interior walls and woodwork and iron components. In order to achieve this, almost every window opening will need to be fitted with some type of passive louvered ventilation. Installation of window-mounted passive louver systems is covered in the **Windows** section of this handbook. For more information on lighthouse ventilation refer to the **Interiors** section.

Figure 11. These replacement lighthouse doors have screened louvers that cover approximately 25% of the door opening to maximize air exchange.

Fire Protection

Despite the fact that concrete lighthouses are constructed of noncombustible materials, fire can still be a threat to their preservation. The impacts of a fire are devastating and will often cause serious irreversible damage and loss to historic interior fabric. For guidance on these issues, refer to "Fire Protection and Protection Objectives" under **Related Activities** in Part VI.

Planning for Concrete Repair

Whatever the causes of deterioration, careful analysis, supplemented by testing, is vital to the success of any historic concrete repair project. Undertaken by experienced engineers or architects, the basic steps in a program of testing and analysis are document review, field survey, testing, and analysis.

- ***Document review:*** While plans and specifications for historic concrete lighthouses are rarely extant, they can be an invaluable aid, and every attempt should be made to find them. They may provide information on the intended composition of the concrete mix, or on the type and location of reinforcing bars. Old photographs, records of previous repairs, documents for lighthouses of the same basic construction or age, and news reports may also document original construction or changes over time.
- ***Field survey:*** A thorough visual examination can assist in locating and recording the type, extent, and severity of stress, deterioration, and damage.
- ***Testing:*** Two types of testing, onsite and laboratory, can supplement the field condition survey as necessary. Onsite, nondestructive testing may include use of a calibrated metal detector or sonic tests to locate the position, depth, and direction of reinforcing bars. Voids can frequently be detected by "sounding" with a metal hammer. Chains about 30 inches long attached to a 2-foot-long crossbar, dragged over the slabs while listening for hollow reverberations, can locate areas of slabs that have delaminated. In order to find areas of walls that allow moisture to penetrate to the lighthouse interior, areas may be tested from the outside by spraying water at the walls and then inspecting the interior for water. If leaks are not readily apparent, sophisticated equipment is available to measure the water permeability of concrete walls.

  If more detailed examinations are required, nondestructive instruments are available that can assist in determining the presence of voids or internal cracks, the location and size of rebars, and the strength of the concrete. Laboratory testing can be invaluable in determining the composition and characteristics of historic concrete and in formulating a compatible design mix for repair materials. These tests, however, are expensive. A well-equipped concrete laboratory can analyze concrete samples for strength, alkalinity, carbonation, porosity, alkali-aggregate reaction, presence of chlorides, and past composition.
- ***Analysis:*** Analysis is probably the most important step in the process of evaluation. As survey and test results are revised in conjunction with available documentation, the analysis should focus on determining the nature and causes of the concrete problems, on assessing both the short-term and long-term effects of the deterioration, and on formulating proper remedial measures.

Repair

Repairs should be undertaken only after the planning measures outlined above have been followed. Principal concrete repair treatments are discussed below. While they are presented separately here, in practice, preservation projects typically incorporate multiple treatments. When performing any of the following treatments, the gentlest means possible should be used.

The following general guidelines should be followed when performing any treatment on a concrete lighthouse.

- Identify, retain, and preserve concrete features that are important in defining the overall historic character of the lighthouse.
- Identify finished surface texture, color, and coatings. Some walls bear the impression of wooden form boards used during construction. Any repairs made to surfaces with such impressions should reproduce the same finish to disguise the repaired area.
- When determining the best treatment for coating removal, coating application, or applied patches, test panels should be prepared using the proposed treatments in inconspicuous locations.
- Identify the age and potential inherent preservation problems in original materials or construction methods, which may require laboratory analysis. Any rehabilitation plan must be based on a thorough knowledge of the properties of the original materials.
- Identify type and location of reinforcing bars.
- Be sure to evaluate and treat the various causes of deterioration, such as leaking roofs or gutters, differential settlement of the lighthouse, capillary action (such as rising damp), or chloride contamination.
- Do not remove or radically change concrete features that are important in defining the overall historic character of the lighthouse.

Cleaning

Clean concrete only when necessary to halt deterioration. Heavy soiling, bird debris, ferrous stains, graffiti, and biological growth can trap moisture and damaging chemicals against the surface of the concrete, initiating and sustaining deterioration. Consider the following guidelines to prevent soiling and to determine the most effective cleaning methods.

- Cover areas where pigeons roost with specially manufactured and sensitively installed bird netting.
- Conduct concrete cleaning tests if cleaning is appropriate. Tests should be observed over a sufficient period of time to assess both the immediate and the long-range effects of cleaning. Clean concrete surfaces with the gentlest method possible, such as a low-pressure water rinse using a mild detergent applied with natural bristle brushes. Chemicals applied as a poultice may be necessary to remove tenacious stains without abrading surface texture or detail. After treatment, thoroughly rinse the surface of all residual chemicals.
- Do not use a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures.
- Do not clean with chemical products that will damage concrete. When using chemical cleaning products, be sure to rinse the surface clean of chemicals.
- Do not apply high-pressure water cleaning methods that will damage historic surface treatment or coating and drive water into the wall, causing corrosion of the steel reinforcing bars.

Coatings

As a protective measure and for identification as a daymark, most concrete lighthouses had an external coating. The external coating was the first line of defense against the elements. Typically this was either a paint, stucco, or in some cases whitewash or lime-mortar-wash coating. As part of preserving the lighthouse, all coatings must be maintained.

Each type of coating protected the lighthouse in a slightly different manner. Paint provides a film over the concrete that prevents water from penetrating. Stucco is a three-layer mortar-and-sand shell that bonds to the concrete to prevent water from penetrating. Whitewash and lime mortar wash are lime-and-water-based "sacrificial" coatings that protect the lighthouse by slowly deteriorating as they weather.

The key to the preservation of an external coating system, especially a lighthouse coating that is subjected to severe marine environment conditions, is a complete understanding of the mechanics of the system. Whether simply touching up the coating or following through with a complete restoration of the external coatings, it is wise to seek the advice of paint manufacturers' technical representatives.

All external coatings, especially paints which may date from the early 20th century, should be tested for lead and asbestos content. If lead or asbestos is present, local codes on health, life safety, and environmental requirements must be met. Lead or asbestos found in otherwise sound paint layers, does not dictate the removal of that paint. In most cases it is far safer and more cost-effective to leave intact paint areas in place. For further information refer to NPS *Preservation Briefs 37: Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing.*

Refer to the **Masonry** section for more information on the repair of stucco and lime-mortar-wash coatings.

When performing coating removal and reapplication on a historic concrete lighthouse, consider the following general guidelines:

- Inspect painted and stuccoed concrete surfaces to determine whether recoating is necessary. Failed coatings are characterized by flaking or loss of adhesion.
- Locate areas of delaminated stucco and incipient concrete spalls by sounding. Spalled concrete or delaminated stucco will reverberate with a distinctly hollow sound.
- Remove damaged or deteriorated coating only to the next sound layer using the gentlest method possible (e.g., hand scraping) before recoating.
- Evaluate the overall condition of the concrete to determine if protection and maintenance are sufficient, or if material analysis and repairs are necessary.

Coating Removal

When there is extensive failure of the protective coating, most or all of the paint must be removed to prepare the surfaces for new protective coatings. The selection of an appropriate technique depends upon how much paint failure and concrete deterioration has occurred. Local environmental regulations may restrict the options for cleaning and paint removal methods, as well as the disposal of materials.

Many of these techniques are *potentially dangerous* and should be carried out only by experienced and qualified workers using proper personal protective equipment such as full-face respirators, eye protection, protective clothing, and optimum workplace safety conditions. Before selecting a process, test panels should be prepared on the concrete to be cleaned to determine the relative effectiveness of various techniques. The cleaning process will very likely expose additional coating defects, cracks, and deterioration that may not have been obvious before.

The following are guidelines to consider when removing coatings from historic concrete lighthouses:

- Proven paint removal methods include: water based paint strippers designed for concrete use, *low* pressure needle guns, and hand scraping.

(For more information on the use of needle guns refer to the case study on the rehabilitation work performed at Anacapa Island Lighthouse in Part V., **Beyond Basic Preservation**.)

- Do not sandblast concrete surfaces using dry or wet abrasives. This treatment will permanently erode the surface of the material and accelerate deterioration.
- Do not remove paint or stucco from a historically coated concrete lighthouse and not recoat, thus changing the appearance.
- Do not remove sound stucco, then recoat the entire lighthouse only to achieve a uniform appearance.
- Do not remove paint or stucco by methods that destroy concrete, such as sandblasting, application of caustic solutions, or high-pressure water blasting.

Recoating

A thorough study of materials is recommended before starting any coating program. An understanding of the substrate, or base material, must also be had. This can best be achieved by a thorough inspection of both the substrate and the existing coating system. Any areas of deteriorated substrate should be examined and repaired before recoating.

Coatings applied to masonry surfaces should 'breathe'. This means the coating should allow the transpiration of moisture at the microscopic level. Modern paint coatings are able to do this. A successful coating system for exterior concrete surfaces is to use an acrylic primer with an elastomeric acrylic top coat with mold and fungus inhibitors, mineral oxide pigments, and freeze-thaw stabilizers. A successful coating system for interior concrete is to use an acrylic primer and a 100% acrylic emulsion top coat with a minimum 55% permeability rating. This coating system will allow the concrete to breathe, thus allowing moisture in the concrete to escape.

- Apply compatible coating systems following proper surface preparation. Testing is mandatory to ensure that replacement material is compatible with the aesthetic and physical properties of the existing fabric and to determine short- and long-term adverse effects.
- Recoat with materials, textures, and colors that are historically appropriate to the lighthouse.
- Follow the manufacturer's specifications for surface preparation and application of paint. This will ensure that the coating will perform as designed. For more information on types of masonry paints currently being used in the field, refer to the case study on Anacapa Island Lighthouse in Part V., **Beyond Basic Preservation**.
- Use brushes to apply coatings. Brush application will provide the best coverage as well as be historically accurate. The use of brushes will also eliminate the need to contain overspray that is associated with spray applications.
- Do not apply paint or other coatings such as stucco to concrete in a manner that creates a new appearance.

Damaged Concrete Repair

Repair of historic concrete may consist of either patching the historic material or filling in with new material worked to match the historic material. If replacement is necessary, duplication of historic materials and detailing should be as exact as possible to assure a repair that is functionally and aesthetically acceptable. The correction and elimination of concrete problems can be difficult, time-consuming, and costly. Yet the temptation to resort to temporary solutions should be avoided, since their failure can expose a lighthouse to further and more serious deterioration, and in some cases can mask underlying structural problems that could lead to serious safety hazards.

The following are guidelines to consider when repairing damaged or deteriorated historic concrete.

- ***Repair of Cracking***

  Hairline, nonstructural cracks that show no sign of worsening normally need not be repaired. Cracks larger than hairline cracks, but less than approximately one-sixteenth of an inch, can be repaired with a mix of cement and water. If the crack is wider than one-sixteenth of an inch, fine sand should be added to the mix to allow for greater compatibility, and to reduce shrinkage during drying. Field trials will determine whether the crack should be routed (widened and deepened) minimally before patching to allow sufficient penetration of the patching material. To ensure a long-term repair, the patching materials should be carefully selected to be compatible with the existing concrete as well as with subsequent surface treatments such as paint or stucco.

  When it is desirable to reestablish the structural integrity of a concrete lighthouse involving dormant cracks, epoxy injection repair should be considered. An epoxy injection repair is made by sealing the crack on both sides of a wall or a structural member with an epoxy mortar, leaving small holes, or 'ports' to receive the epoxy resin. After the surface mortar has hardened, epoxy is pumped into the ports. Once the epoxy in the crack has hardened, the surface mortar can be ground off, but the repair may be visually noticeable. (It is possible to inject epoxy without leaving noticeable patches, but the procedure is much more complex and is beyond the scope of this text.)

  Other cracks are active, changing their width and length. Active structural cracks will move as loads are added or removed. Thermal cracks will move as temperatures fluctuate. Thus, expansion-contraction joints may have to be introduced before repair is undertaken. Active cracks should be filled with sealants that will adhere to the sides of the cracks and will compress or expand during crack movement. The design, detailing, and execution of sealant-filled cracks require considerable attention, or else they will detract from the appearance of the historic lighthouse.

  Random (map) cracks throughout a structure are difficult to correct, and may be unrepairable. Repair, if undertaken, requires removing the cracked concrete. A compatible concrete patch to replace the removed concrete is then installed. For some lighthouses without significant historic finishes, an effective and economical repair material is probably a sprayed concrete coating, troweled or brushed smooth. Because the original concrete will ultimately contaminate new concrete, lighthouses with map cracks will present continuing maintenance problems.

- ***Repair of Spalling***

  Repair of spalling entails removing the loose, deteriorated concrete and installing a compatible patch that dovetails into the existing sound concrete. In order to prevent future crack development after the spall has been patched and to ensure that the patch matches the historic concrete, great attention must be paid to the treatment of rebars, the preparation of the existing concrete substrate, the selection of compatible patch material, the development of good contact between patch and substrate, and the curing of the patch.

  Once the deteriorated concrete in a spalled area has been removed, rust on the exposed rebars must be removed by wire brush or sandblasting. An epoxy coating applied immediately over the cleaned rebars will diminish the possibility of further corrosion. As a general rule, if the rebars are so corroded that a structural engineer determines they should be replaced, new supplemental reinforcing bars will normally be required, assuming that the rebar is important to the strength of the concrete. If not, it is possible to cut away the rebar.

  Proper preparation of the substrate will ensure a good bond between the patch and the existing concrete. If a large, clean break or other smooth surface is to be patched, the contact area should be roughened with a hammer and chisel. In all cases, the substrate should be kept moist with wet rags, sponges, or running water for at least an hour before placement of the patch. Bonding between the patch and substrate can be encouraged by scrubbing the substrate with cement paste, or by applying a liquid bonding agent to the surface of the substrate. Admixtures such as epoxy resins, latexes, and acrylics in the patch may also be used to increase bonding, but this may cause problems with color matching if the surfaces are to be left unpainted.

  Compatible matching of patch material to the existing concrete is critical for both appearance and durability. In general, repair material should match the composition of the original material (as revealed by laboratory analysis) as closely as possible so that the properties of the two materials, such as coefficient of thermal expansion and strength, are compatible. Matching the color and texture of the existing concrete requires special care. Several test batches of patching material should be mixed by adding carefully selected mineral pigments that vary slightly in color. After the samples have cured, they can be compared to the historic concrete and the closest match selected.

Contact between the patch and the existing concrete can be enhanced through the use of anchors, preferably stainless-steel hooked pins, placed in holes drilled into the structure and secured in place with epoxy. Good compaction of the patch material will encourage the contact. Compaction is difficult when the patch is 'laid-up' with a trowel without the use of forms; by building up thin layers of concrete, however, each layer can be worked with a trowel to achieve compaction. Board forms will be necessary for large patches. In cases where the existing concrete has a significant finish, care must be taken to pin the form to the existing concrete without marring the surface. The patch in the form can be consolidated by rodding or vibration.

Because formed concrete surfaces normally develop a sheen that does not match the surface texture of most historic concrete, the forms must be removed before the patch has fully set. The surface of the patch must then be finished to match the historic concrete. A brush or wet sponge is particularly useful in achieving matching textures. It may be difficult to match historic concrete surfaces that were textured, as a result of exposed aggregate for example, but it is important that these visual qualities be matched. Once the forms are removed, holes from the bolts must also be patched and finished to match adjacent surfaces.

Regardless of size, a patch containing cement binder (especially Portland cement) will tend to shrink during drying. Adequate curing of the patch may be achieved by keeping it wet for several days with damp burlap bags. Note that although greater amounts of sand will reduce overall shrinkage, patches with a high sand content normally will not bond well to the substrate.

- ***Repair of Deflection***

  Deflection can indicate significant structural problems and often requires the strengthening or replacement of structural members. Because deflection can lead to structural failure and serious safety hazards, its repair should be left to engineering professionals.

- ***Repair of Erosion***

  Repair of eroded concrete will normally require replacing lost surface material with a compatible patching material (as outlined above) and then applying an appropriate finish to match the historic appearance. The elimination of water coursing over concrete surfaces should be accomplished to prevent further erosion. If necessary, drip grooves at the underside of overhanging edges of sills, belt courses, cornices, and projecting slabs should be installed.

Limited Replacement In Kind

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the *limited replacement in kind* of extensively deteriorated or missing *parts* of features when there are surviving prototypes (for example, concrete cornices and door pediments, window architraves, gallery brackets, etc). The replacement material needs to match the old both physically and visually, i.e., gray, portland-cement-based concrete needs to be replaced with gray, portland-cement-based concrete. Thus, with the exception of hidden structural reinforcement and new mechanical system components, substitute materials are not appropriate in the treatment *preservation*. Again, it is important that all new material be identified and properly documented for future research.

If prominent features are missing, then a *rehabilitation* or *restoration* treatment may be more appropriate.

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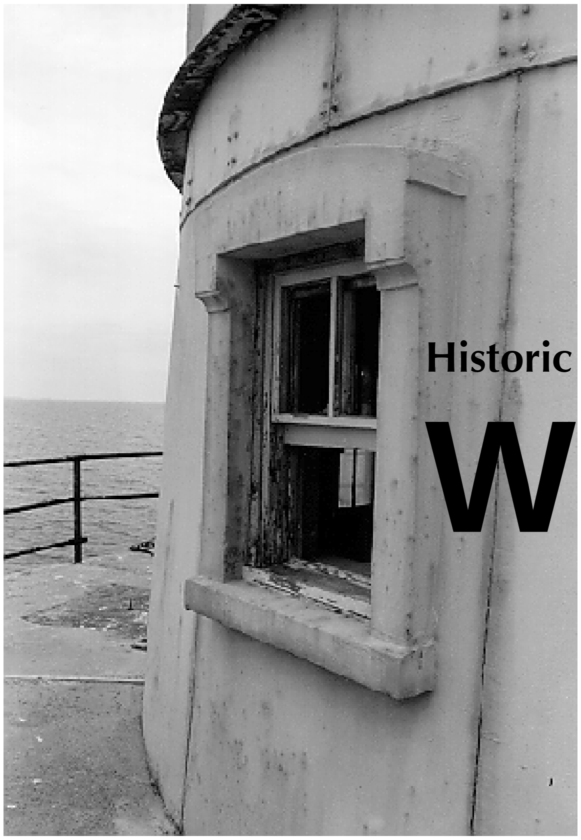


Historic Lighthouse Preservation:

WINDOWS

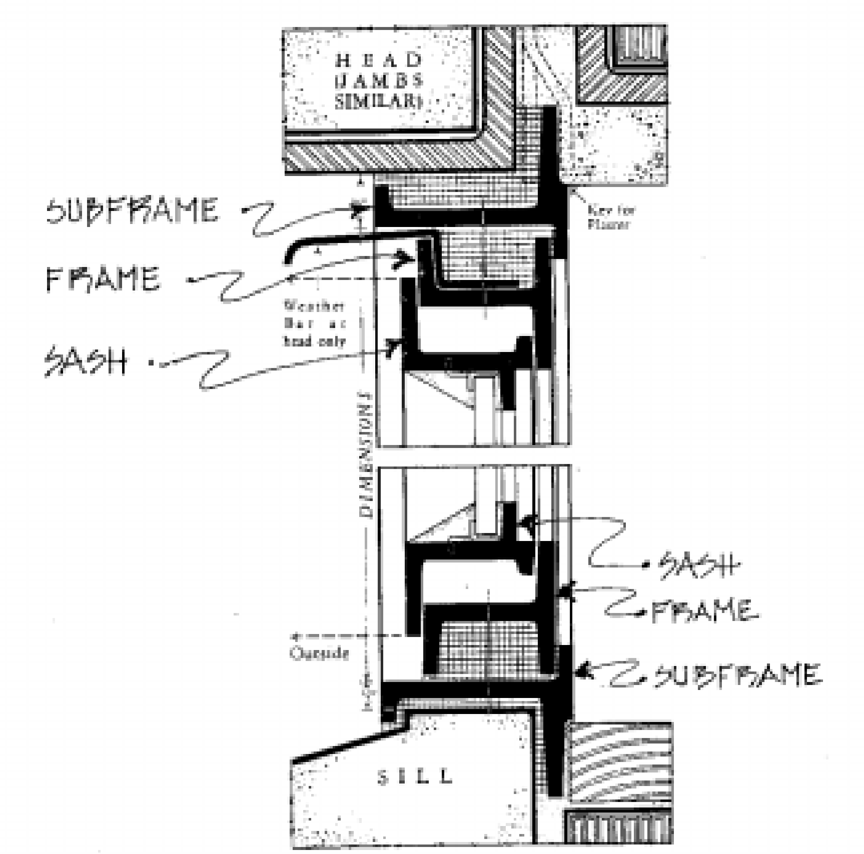
Figure 1. Close-up of a window found in a Chesapeake Bay "spark plug" lighthouse . The integral cast-iron trim is a typical character-defining feature of this lighthouse type from the late 19th century

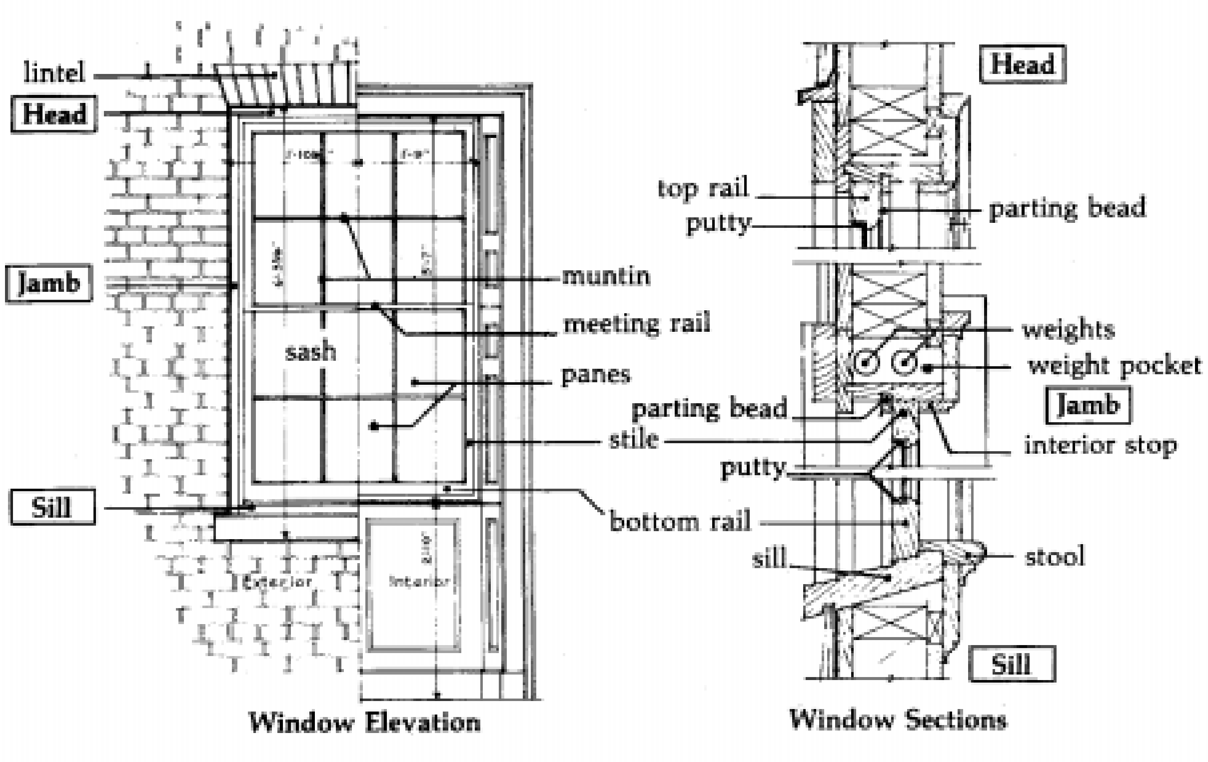
With their functional and decorative features such as keystone lintels, multi-light sashes, arched pediments, and architrave (trim or molding which surrounds the window opening), windows can be extremely important in defining the overall character of a lighthouse. Usually windows were integral components of a historic lighthouse's stylistic design and featured hallmark elements that defined the architectural style upon which the ornament of the structure was based.

The predominant window type found in historic lighthouse towers is a wood, double-hung sash variety. This window type has been used since the late 18th century. Other window types associated with lighthouses are wood and metal casement windows.

The primary cause of lighthouse window deterioration is moisture penetrating the various components through rain driven against and into windows, standing water on sills, and interior condensation. In a marine environment, deterioration caused by moisture penetration is exacerbated by extended periods of damp weather, which prevent windows from drying out, thereby encouraging expansion and rot. Other factors that contribute to window deterioration are poor design, vandalism, insect/fungal attack, settlement over time, paint buildup, broken glazing, deteriorated putty, and deferred maintenance.

Windows admit light and air into a lighthouse. Both of these functions should be maximized, but in a controlled manner. Because most lighthouses are unoccupied, mechanical methods are not always viable as a means of interior climate control. Well-maintained, operable windows will therefore be an important and preferred component in creating an efficient passive ventilating system. Replacement windows and components, when needed, should be constructed of materials of the highest





Figures 2 and 3. Wood and metal window details (source: *The Window Handbook*).

quality that can withstand a harsh marine environment. Where vandalism and security require the temporary blocking of a window to better secure the structure, sensitive measures can effectively block the opening with minimal damage to the historic window. The following is a discussion of preferred preservation methods to consider when preserving historic lighthouse windows.

Window Types

The two primary types of windows found in historic lighthouses are identified by how their moving parts operate. The wood double-hung sash is the most common. The moving parts of the window consist of two wood frames, called sashes, that capture the glass 'lights' or panes of the window. These frames are housed in a wood frame, called a jamb, that allows the sashes to slide up and down. The top of the wood frame is called the head and the bottom portion is called the sill on the exterior and the stool on the interior. The sill is responsible for shedding water away from the window opening. The second most common window type found in historic lighthouses is the metal casement. The moving parts of a metal casement window operate like a door. The terminology remains the same for the parts of the casement window.

Inspection and Evaluation

The first step to repairing historic windows is a thorough inspection of each window unit.

Inspection Chart for Lighthouse Windows	
Look For:	*Possible Problems:*
Wood Windows	
Areas of paint failure	This may indicate the wood is in poor condition and in need of repair. Wood is frequently in sound condition, however, beneath unsightly paint. After noting areas of paint failure, inspect the condition of the wood. Use an ice pick or an awl to test wood for soundness. Pry up a small section of the wood. Sound wood will separate in long fibrous splinters. Decayed wood will lift up in short irregular pieces caused by breakdown of fiber strength.
Deteriorated wood	If deterioration has begun from within the wood member and the core is badly decayed, the visible surface may appear to be sound. Pressure on a probe can force through an apparently sound outer layer to penetrate deeply into decayed wood. This technique is especially useful for checking sills where visual access to the underside is restricted.

Look For:	*Possible Problems:*
Metal Windows	
Areas of paint failure	This may indicate the paint is at the end of its effective life span or the window has been bent or deformed. Bending makes the less flexible paint fracture and 'pop' off the window frame.
Areas of corrosion on all surfaces of the sash, frame, sub-frame (if visible), and hardware	This may indicate a moisture infiltration problem. Corrosion in the form of rust will occur typically inside the frame channel and along the bottom edge of the sash.
Bowing or misalignment of window parts	Deformation could be the result of misuse/abuse or corroding components that have deformed because of rust-jacking or deterioration.
Both Window Types	
Water entering around the edges of the frame	The joints or seams should be caulked to eliminate this danger. Check the glazing for cracked, loose, or missing sections. Examine the sill for a downward slope which allows water to drain.
Condition of glass and glazing to determine the extent of required repairs	Careful probing of the glazing with an awl will aid in determining its soundness.
Gaps or cracks in the joint between the window frame and the lighthouse wall	Cracks or gaps are possible water infiltration points.
Moving parts of the windows	Bound or tight operating windows may simply be painted shut or may be stuck because of deteriorating frame members or sash frames, or bound because of corroded hardware.

PRESERVATION TREATMENTS

The following are protection/stabilization (mothballing) and repair treatments designed specifically for windows found in historic lighthouse towers. For a discussion of window treatments in ancillary structures, see NPS *Preservation Briefs 9: The Repair of Historic Wooden Windows* and *Preservation Briefs 13: The Repair and Thermal Upgrading of Historic Steel Windows*.

Protection and Stabilization (Mothballing)

Lighthouses which have been mothballed usually have had the openings on the lower level covered to protect fragile glass windows from breaking and to prohibit entry points. Infill materials for closing window openings include plywood, corrugated sheet-metal panels, metal grates or grills, brick, and cinder or cement blocks (in masonry lighthouses). The method of installation should not damage the opening or window jamb. During this procedure all associated sash, shutters, and frames should be protected. If removed, all window parts should be labeled to indicate which window they came from and stored for future reuse. Special care must be taken to ensure no further damage is incurred during the removal of the window parts.

- For windows, the most common security feature is the closure of the openings; this may be achieved with wooden or preformed panels or, as needed, with metal sheets or in the case of masonry towers concrete blocks or bricks may be used. Plywood panels, properly installed to protect window frames and which are properly ventilated, are the preferred treatment from a preservation standpoint. (To provide adequate ventilation the louvered opening should have an area that is approximately half of the original sash opening.)
- There are a number of ways to insert vented plywood panels into window openings to avoid damage to frame and sash. One common method is to bring the upper and lower sash of a double-hung unit to the midpoint of the opening and then to install pre-cut plywood panels on the inside face of the window using long carriage bolts anchored into horizontal wooden bracing, or strong backs (see Figures 4 and 5).
- The type of ventilation should not undermine the security of the building. The most secure installations use custom-made grills well anchored to the window frame, often set in plywood security panels. In upper-level windows vents formed using heavy millwork louvers set into existing window openings are another possibility (see Figure 6).

WPTC photo

Figure 4. A good example of a blocked window using a metal panel fitted with a hooded vent. For more adequate ventilation, the vent should be larger.

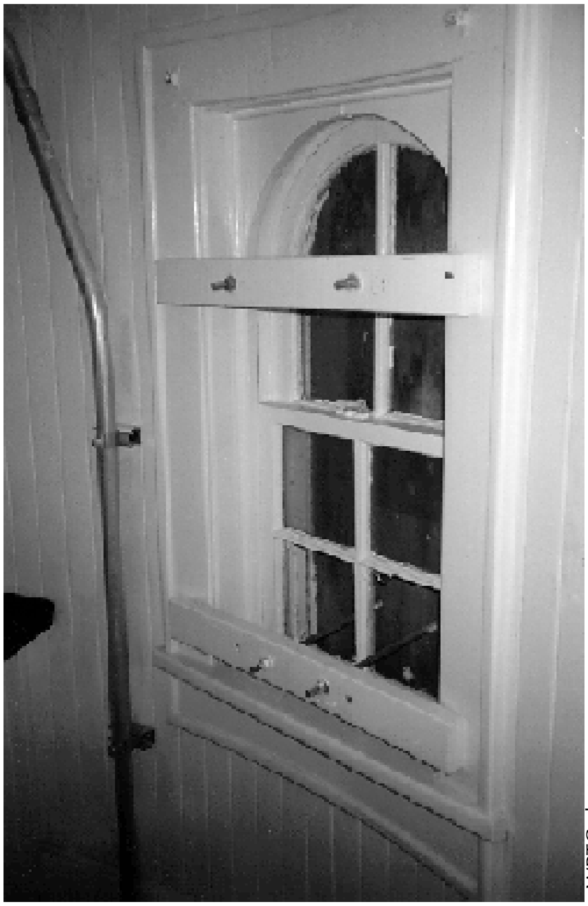


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Figure 5. Interior view of the blocked window. If possible, a better solution would have been to raise the lower sash and lower the upper sash and pass the bolts through the openings.

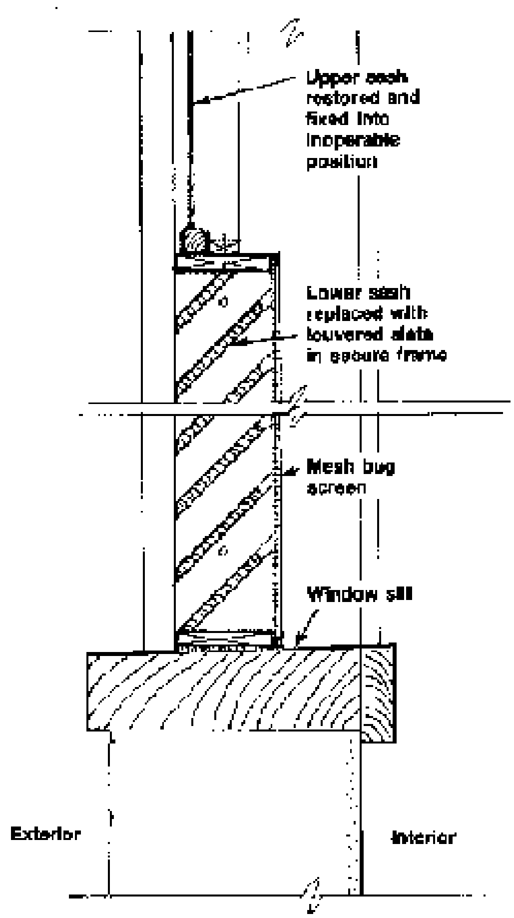

Figure 6. Detail of wood louver system designed to be inserted into lower sash opening after sash has been carefully removed. (Drawing by Thomas Vitanza, WPTC)

- Plywood panels are usually 1/2- to 3/4-inch (1.25-1.875 cm.) thick and made of exterior grade stock, such as CDX, or marine-grade plywood. They should be painted to protect them from delamination and to provide a neater appearance. These panels may be painted to resemble operable windows or treated decoratively.
- As a temporary treatment, acrylic or other high impact clear sheeting could be used to cover an entire window. The sheeting could either be attached to the actual window frame with screws, being careful not to damage any historic molding profiles or split the wood frame. A better attachment method (especially for masonry lighthouses) would be to construct a sub-frame within the window opening using 2- by 4-inch framing members and then attach the sheeting to the sub frame. If this method is used, the interior sash should be opened and the sheeting fitted with large screened louvers. (To provide adequate ventilation, the louvered opening should have an area that is approximately half of the original sash opening.) When using this treatment, the sheeting must be ventilated to ensure that condensation, which could accelerate the deterioration of the window, does not build up between the panel and the window.
- Another effective method of ventilating a lighthouse during mothballing is to lower the upper sash and install a large screened, hooded vent. These vents, together with the louvers fitted in the tower entry door, keep the interior of the tower free from condensation year round.

Repair

The following is a discussion of maintenance and repair philosophy and treatments for historic lighthouse windows. These instructions conform with the principle that the least modification to an existing window often yields the greatest return—accepted preservation practice and simple economics; the ratio of investment to return is often greater when repairing and upgrading an existing window than when replacing it.

- Identify, retain, and preserve windows (their functional and decorative features) that are important in defining the overall historic character of the building. Such features can include frames, sash, muntins, glazing, sills, heads, hood molds, paneled or decorated jambs, moldings, hardware, and interior and exterior shutters and blinds.
- When determining its historic significance, consider a window's place as a principle character-defining component of the exterior facade and its contribution to an interior space.
- Avoid changing the historic appearance of windows through the use of inappropriate designs, materials, finishes, or colors which noticeably change the sash, depth of reveal, or muntin configuration; the reflectiveness and color of the glazing; or the appearance of the frame.
- Conduct an in-depth survey of the conditions of windows early in preservation planning so that repair and upgrade methods and possible replacement options can be fully explored.
- When possible preserve all remaining original glazing. Historic glass often has distortions and imperfections that are not found in modern glass—an irreplaceable character-defining element.
- Evaluate the overall condition of materials to determine whether more than protection and maintenance are required, i.e., whether repairs to windows and window features are needed.
- Keep glazing clear to maximize the natural light source. Glass is preferred to plastics such as acrylic and polycarbonate which may scratch easily, tend to look oily, and will yellow and haze with time.
- Preserve operating systems for historic windows, (e.g., weights on double-hung windows), repairing or replacing components as needed. This should done even though the windows may not be currently used.
- Repair all broken, cracked, or missing glass immediately. If immediate replacement is not feasible, a temporary patch should be used to prohibit the entry of water, pests, and vandals. When funds are available the missing glass should be replaced.
- Where building or life-safety code requires, install safety glass into existing window sashes, carefully retaining frame and hardware components. If possible, salvage original glass for later reinstallation or use elsewhere in the structure. These codes are enforced at a local or state level and typically apply to lighthouses that are privately owned where visitors have unsupervised access to the tower.
- Remove rust and paint from metal windows by hand scraping. Low pressure (80-100 psi) sandblasting may be used to remove heavy corrosion, with careful protection of glass and surrounds. Do not use heat to remove rust or paint from metal windows; this can distort the metal members, release toxic fumes, and may cause the glazing compound to fail. If the sash is removed from the frame, the paint can be removed through a chemical dip process, but the metal surface should be neutralized before repainting.
- Do not obscure historic window trim with metal, vinyl, or other material.
- Do not strip windows of historic material such as wood, cast iron, or bronze.

Figures 7 through 9 illustrate forms of deterioration typical to lighthouse windows. All of these conditions are repairable and do not require total replacement. The following guidelines are intended to aid in the repair of such deterioration.

- Once the damage and deterioration have been identified, the affected areas must be treated. Repair window frames and sash by patching, splicing, consolidating, or otherwise reinforcing. Such repair may also include replacement of

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Figure 7. Deteriorated glazing putty and peeling paint on a multilite wood sash.

those parts that are extensively deteriorated or missing, using surviving prototypes such as architraves, trim, hood molds, sash, sills, and interior or exterior shutters and blinds.

- Repair defective sills to permit positive drainage away from the window sash. Poor design of the exterior window sill is a frequent problem; window deterioration usually begins on horizontal surfaces and at joints where water collects, saturating wood and corroding metal.
- Repair of historic windows is always preferred to replacement. Usually the sill must be replaced first, then lower sash parts. Splicing and dutchmen can be effective repair methods for both wood and metal window elements.
- If replacement is required, limit it to severely deteriorated components.
- Clean and oil hardware that has been painted over; in most cases, repair, rather than replacement, should be possible.
- Remove built-up paint on sashes and frames that causes sashes to be inoperable. Where possible, remove paint only to the next sound layer. In order to provide a paint chronology, a patch of sound paint should be left undisturbed for future reference.

WPTC photo

Figure 8. Deterioration of the bottom rail and sill on a wooden double-hung window.

WPTC photo

Figure 9. Rust occurring on the inside of the steel channel that forms the sill of this metal casement window.

- When possible, remove earlier repairs that have been insensitive to the historic features and materials, and repair according to accepted standards.
- Document all work through written and photographic means as a record for future reference.

Removing Paint from Wood Windows

NOTE ABOUT LEAD PAINT: In the following treatment explanations references are made to the removal of loose, flaking, and blistering paint finishes; in carrying out this treatment, all precautions should be taken to protect the workers from exposure to lead-based paint.

Historic wood windows tend to accumulate many layers of paint. This paint is likely to interfere with the proper operation of the window and is usually visually unattractive. Over time, partial peeling leaves a pitted surface that encourages moisture to collect. Excessive paint layers also obscure the shape of original molding profiles, which add definition to the window's appearance.

The extent of paint removal required depends on the condition of the paint. Treatments for common paint conditions found on historic lighthouse windows:

- ***Chalked paint:*** Clean with a mild detergent solvent, hose down, and allow to dry before repainting.
- ***Crazed paint:*** Sand by hand to the next sound layer before repainting; exposure of bare wood is not necessary.
- ***Peeling and blistering:*** Analyze between coats as to the source. If salts or impurities have caused peeling, scrape off the defective surface, hose off the underlying surface, and wipe surface dry before repainting. If the peeling or blistering was caused by incompatibility of the paints or improper application, scrape off the defective surface, and sand the underlying surface to provide a better bond with the new paint. Peeling, cracking, and alligatoring to bare wood require total removal of the defective paint followed by drying out of the wood substrate and treatment for any rotted areas before repainting. Sand or scrape only to the next sound layer of paint, exposure of bare wood is not necessary.

Paint Removal Methods

Paint is typically removed from wood surfaces by scraping after it has been softened with heat guns or plates or brushed with commercially available chemical stripping solvents. Regardless which method is chosen for paint removal, after the stripping process is complete, all affected areas will need at least light sanding.

Chemical Strippers

WARNING: When chemical paint removers are used, take care to protect your skin and eyes, provide adequate ventilation, and prevent spillage onto adjacent materials. These solvents can etch or otherwise damage the surrounding masonry, painted surfaces, and glazing. It is best not to use these chemicals on or directly adjacent to glass.

Paint on historic lighthouse window sash can be removed by softening with commercial chemical strippers such as methylene chloride, toluol, or xylol. To maximize the chemical's effect, the stripping agents have been combined with a thickener which holds them in place while the chemicals soften the paint. The softened paint is scraped with special scraping tools designed not to damage existing molding profiles. The scrapers can be formed on site by grinding the trim profile on the end of a large (2-inch-wide) scraper. Commercially available scrapers are designed with different sized curves and shapes that can be used in combination to fit the various curves and shapes of the molding profile.

Another commercially available method sandwiches the paint, softened by a solvent paste, between the wood substrate and a disposable membrane. Although materials for this method are more costly, it is less labor intensive than using traditional strippers and scraping. Even with this system some scraping is required. With either stripping method all stripped surfaces must be neutralized for the new paint to properly adhere. The neutralization method depends on the particular stripper.

Applied Heat

WARNING: Under no circumstances should a torch or other open flame be used to remove paint. When using heat to strip paint, be sure to provide adequate ventilation, properly protect skin and eyes, and wear a respirator designed for vapors. Take all precautions to protect workers from lead-paint exposure.

There are two commercially available applied-heat paint-removal systems for use on historic windows: heat guns and heat plates. Heat guns will soften paint in only a small concentrated area, making heat guns good for removing paint in trim profiles and other tight spaces. A heat gun can be used to soften and remove glazing compound only if certain precautions are taken to protect the glass. When a heat gun is used near glass, carefully cover the glass with a piece of hardboard wrapped with aluminum foil. This measure will help reflect heat away from the glass and reduce the chances of localized overheating, which can crack the glass.

To facilitate complete paint removal, remove the existing sash from the frame. To do this, pry loose the stops and parting beads as carefully as possible so that the wood does not split. All parts should be labeled and positions documented to ease reinstallation. If parts are damaged during removal they should repaired or reproduced to maintain the historic appearance of the window. Because window stop profiles have changed very little over the last 100 years, the variety of sizes available at many lumber yards will likely match the historic profile to be replaced.

Once the paint has been removed, revitalize the bare wood by rubbing it with fine-grade steel wool soaked in turpentine or mineral spirits and boiled linseed oil.

After the excess paint from the window frame and sash has been removed, it may be advisable to treat the surfaces with a wood preservative coating. Choose a commercially available preservative, taking care that it is compatible with the finish or paint system to be applied afterward. Solutions containing copper arsenate, for example, give treated wood a greenish tone and are not approved for use by most government agencies.

Removing Paint from Metal Windows

NOTE ABOUT LEAD PAINT: In the following treatment explanations, references are made to the removal of loose, flaking, and blistering paint finishes; during this process all precautions should be taken to protect workers from exposure to lead-based paint.

Historic metal windows often have accumulated many layers of paint, which is likely to interfere with the proper operation of the window and is usually visually unattractive. Over time, partial peeling leaves a pitted surface that collects moisture. Excessive paint layers also obscure the shape of original molding profiles, which add definition to the window's appearance.

The extent of paint removal required depends on the condition of the paint. Treatments for common paint conditions found on historic lighthouses:

- ***Chalked paint*** should be cleaned with a mild detergent solvent, hosed down, and allowed to dry before repainting.
- ***Crazed paint*** should be sanded by hand or with a power sander before repainting.
- ***Peeling and blistering*** between coats should first be analyzed as to the source. If salts or impurities have caused peeling, the defective surface should be scraped off and the underlying surface hosed off and wiped dry before repainting. If peeling or blistering was caused by incompatibility of the paints or improper application, scrape off the defective surface and sand the underlying surface to provide a better bond with the new paint. Peeling, cracking, and alligatoring to bare wood require total removal of the defective paint,

followed by drying out of the wood substrate and treatment for any rotted areas before repainting.

Removing paint from metal frames and sash usually includes removing some built-up corrosion and scaling. Use a wire brush, being careful not to damage the remaining glass or other surfaces. Particular attention is required to remove rust buildup at construction joints and along the crack perimeter of the sash and frame. Because older metal windows were typically primed with lead-based paint, wear a respirator rated for lead protection when using a wire brush. An alternative to abrading the surface, particularly when only light corrosion is present, is to use a liquid gel containing phosphoric, ammonium citrate, or oxalic acid. After the gel has been brushed on and has set, wipe clean and dry the steel substrate. Again, protect surrounding materials, particularly masonry and glass, during all these procedures. After removing the paint, wipe the bare metal with a solvent such as benzene or denatured alcohol to remove all chemical residue.

WARNING: Heat should not be used to remove paint from metal windows because possible distortion may result.

If corrosion is extensive, sandblasting may be necessary. Remove the sash from the frame and the glass panes from the sash. A low-pressure blast (80 to 100 psi) with small grit in the range of #10 to #45) applied with an easily controllable pencil blaster is recommended.

Because corrosion begins as soon as the bare metal is exposed to the air, apply a rust-inhibiting paint immediately after removing old paint. Two coats of zinc-rich chromate paint as a primer are recommended and the finish coat of paint should be from the same manufacturer as the primer to ensure compatibility.

Repainting

NOTE ABOUT PAINTING: The following treatments provide only general information. In preparing surfaces and applying paint, follow manufacturer's specifications and guidelines included with the product (either directly on the label or as included literature) for more specific instructions.

The most time-consuming maintenance procedure is repainting windows. Careful surface preparation is the key to a successful job. In repainting wood windows once the wood has been preserved and its moisture content reduced, select a paint that resists moisture but allows the wood to breathe. Steel windows should be primed with an anticorrosive primer and finished with a compatible paint.

A complex array of paint options have been developed by the modern coating industry. Paints containing lead, used in the past on both wood and metal windows, are no longer readily available. Solvent- and water-based paints used today are generally thicker in composition than the solvent-based paints used historically. When selecting a paint, seek assistance from manufacturers or suppliers about compatibility and methods of application.

When selecting a paint consider these factors:

- drying and recoating time
- coverage
- environmental factors, such as toxicity and flammability
- color and gloss durability
- moisture permeability (in wood windows)
- expected service life
- compatibility with window putty
- tolerance to adverse weather conditions
- adhesion between contacting surfaces

Wood Windows

The earliest water-based paints, now often referred to as latex, were developed for use on interior surfaces and performed poorly on exterior surfaces. For wood windows exterior water-based vinyl acrylic paints are generally more compatible with existing paint layers containing lead and provide better moisture permeability than water- or solvent-based alkyd paints. If the paint layer is impermeable, it may trap water that penetrates past the paint film. Alkyd paints available in flat, semigloss, and gloss finishes are fast drying, flexible, resistant to chalking, and retain color and gloss well, but are incompatible with existing paint layers containing lead.

Metal Windows

Before painting, pits that were created by corrosion should be filled by melting steel welding rod into the pits; then grind flush or use a steel-based epoxy than can be ground or sanded flush with the surrounding material. After the voids have been filled, all bare metal surfaces should be wiped with a solvent-metal-preparation solution. This will remove any chlorides (salt deposits) that may have settled on the surface from the sea air as well as microscopic rust or corrosion that may have started to form. All bare metal surfaces should be coated with a corrosion-inhibiting primer. A solvent-based alkyd paint rich in zinc or zinc chromate is generally recommended as a primer for steel windows along with two impermeable alkyd finish coats.

Caulking and Glazing Compounds

Caulking and glazing compounds are used to seal a window's nonoperable joints. Because their expected service life varies from 5 to 30 years when the window unit is properly maintained, they are considered a disposable part of the window system and therefore receive periodic maintenance. Replacing cracked or missing compounds is somewhat complicated because new materials have been developed in recent decades.

Most traditional caulks and glazing compounds had a base of linseed oil, which tended to became hard and brittle over time. Today, more than a dozen generic compounds are commercially available to fill seams and joints. Most are based on more complex plastic and silicone compounds and tend to remain pliant for a longer time, but not all are useful in window rehabilitation. Because of windows' exposure to temperature extremes and the stresses that develop at the joints where dissimilar materials meet, compounds should be durable, flexible, and resilient.

Caulking

Caulking is used to bridge the joints between the frame and the window opening. These should not be considered stationary joints, for they are constantly moving as the wall and window materials expand and contract because of changes in temperature and moisture content. Selecting an appropriate caulking also depends on the window material itself. The dimensions of a metal window within a window opening, for example, change less than a wood window does. Both, in turn, are more stable than an aluminum window, which has the highest coefficient of thermal expansion and thus requires the most sophisticated caulking.

When selecting caulking be sure to consider the following:

- the material of the window opening (some compounds do not adhere well to porous materials)
- the width of the joint to be sealed (some compounds have a limited gap range)

- the season when caulking is to be applied and the curing time (some of the better compounds require extended periods of warm temperatures above 60° Fahrenheit)
- the caulking's integral color range, often available by custom order
- its adherence to paint

Commonly used window caulks:

- ***Oil-based caulks:*** can seal joints of up to 1/2 inch and are the least expensive, but can require up to a year to cure and temperatures above 40° Fahrenheit for application. They dry hard and can deform permanently. Not paintable.
- ***Butyl rubber caulks:*** can seal joints of up to 1/2 inch, adhere well to metal and masonry, and can be painted upon cure, but require extended temperatures above 40° Fahrenheit for application. They are subject to shrinkage, and some degrade under exposure to ultraviolet light.
- ***Polysulfide caulks:*** can seal joints of up to 1 inch, are flexible and resilient, but are more expensive. They require temperatures above 60° Fahrenheit for application, as well as careful surface preparation and application of a primer over porous surfaces.
- ***Silicone caulks:*** can seal joints of up to 1 inch, are flexible and resilient even at low temperatures, and can be applied at temperatures as low as O° Fahrenheit. They are the most expensive, have limited integral color range, cannot be painted in most cases, and require careful surface preparation and application of a primer over porous surfaces. Only special silicone formulations are paintable.
- ***Polyurethane caulks:*** used in some metal windows, can seal joints of up to 3/4 inch, are flexible and resilient, and adhere well to masonry. They require application at temperatures above 40° Fahrenheit, careful surface preparation, and application of a primer over most surfaces. Not paintable.

When caulking a window, carefully scrape out the existing compound and residue before applying new caulking. If the joint is large and deep, use a filler, known as backer rod, to fill a majority of the void, leaving a gap for the caulk that is approximately as deep as the gap is wide. Then fill this gap with the caulking compound. Protect adjacent masonry surfaces before caulking, since some compounds will stain these materials. Review and strictly follow manufacturer's recommendations and instructions.

Glazing Compounds

Glazing compounds are used to seal the joints where the panes of glass meet the muntins and sash members in older, single-glazed windows. An oil-based putty is typically used on wood sash, while specially formulated glazing compounds are used in steel sash. Most compounds should be protected by paint, but harden with age and rapidly deteriorate when exposed to the elements. Sections of deteriorated glazing compound can often be replaced without removing the sash from the frame. Complete replacement of the compound, however, is best accomplished with the sash on a horizontal surface and the glass removed.

Preparing the Sash

When completely replacing the glazing compound, remove all deteriorated material manually by scraping, taking care not to damage the rabbet, where the glass is positioned. During all operations take every precaution to protect the historic glass.

Wood Windows

If the putty or other compound has hardened in the rabbets, it can be softened by applying heat. A heat gun may be used if the glass is protected by a heat shield (hardboard wrapped with aluminum foil). A better heat source is a heat plate with only a perimeter element and a built-in heat shield that is designed for the purpose of softening putty in wood windows. Before the glass panes are replaced, the surfaces of sash members should be prepared. Clean and finish bare surfaces of wood sash by rubbing the surface with a fine-grade steel wool or a fine grade of high-quality sandpaper, and then apply a solution of equal parts of boiled linseed oil and turpentine. Finally, prime and repaint.

Metal Windows

First, carefully remove all damaged glazing compound and the mounting clips that retain the glass pane. This must be done mechanically. Do not use applied heat, which may cause the window frame to distort. Use a wire brush or, for more severe conditions, a pencil sand blaster at low pressure (80-100 psi) to remove any corrosion. Paint all surfaces with a solvent-based alkyd paint rich in zinc or zinc chromate as an anticorrosive primer. Then apply two coats of a compatible, impermeable alkyd-finish top coat.

Setting the Glass

With wood sash and most steel sash, apply a thin bed of putty along the inside face of the rabbet. This process, known as back-puttying, provides a tight seal and protective cushion for the glass. Insert the glass, replace glazing points (in wood windows) or retaining clips (in metal windows), and putty the exterior face in a neat triangular bead. For metal windows, use only a glazing compound designed for metal windows. For wood windows, use either a linseed-oil putty that is thickened with commercial whiting or a pre-mixed glazing compound. Paint the glazing compound only after it has completely cured. When painting, allow the brush to overlap and drag slightly over the glass to form a durable seal.

Repairing Damaged or Deteriorated Windows

Window repairs, such as splicing new wood, fitting dutchmen, consolidating wood sections, welding steel sections, bending steel sections, replacing glass (see previous section on glazing compounds), and adjusting hardware are generally performed as needed during the course of maintaining a building. Such repairs greatly improve the performance of older windows by returning them to an operable condition.

Splicing and Dutchmen

Deteriorated portions of wood windows can be effectively repaired using like-kind splices or dutchmen. Splicing of a wood member is required when a portion of the window, i.e., a frame rail, has been damaged or has deteriorated and only that portion needs removal and a new section attached in its place. All deteriorated material should be removed, and the end where the replacement member will be attached should be cut on a diagonal to increase the gluing surface area. The replacement member should match the existing members in grain orientation and in any existing shape or profile. The new member can even be made from matching salvaged stock. To attach the new member,

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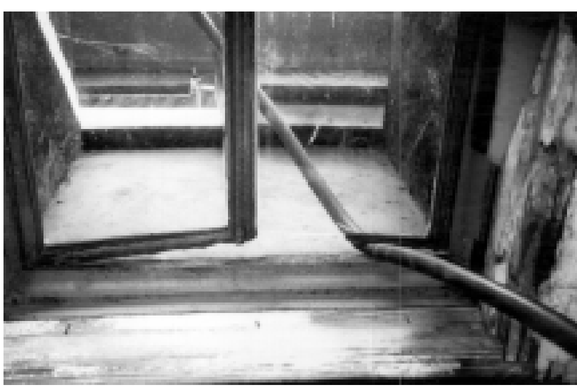
Figure 10. Close-up of a recently restored replacement metal window at Cape Hatteras Lighthouse. Now that the repair work is done, all that this window needs is the hardware lubricated and periodic maintenance to remain in operable condition for the next 50 years. At the time of this lighthouse restoration, it was discovered that the original windows were not repairable and funds were not available to replicate the original cast-iron frame design. The original windows were more like a shutter, constructed in two parts, hinged at both sides and meeting in the middle. The new landing windows were installed as a temporary measure until additional funds are available.

WPTC photo

Figure 11. Example of a metal casement window in a lighthouse dating from the 1870s



WPTC photo

Figure 12. Close-up of severely deteriorated bottom rail of the same window in Figure 11. This condition can be repaired by splicing a new piece of sash

cut the end diagonally to match the existing member; then drill aligned holes in both members for reinforcing dowels.

A 'dutchman' is a fitted patch in a wood member that has only localized deterioration. To fit a dutchman, first probe the deteriorated area to determine the approximate depth of the deterioration. Second, cut a wood patch or dutchman with its grain aligned with the existing member's. The dutchman can be rectangular or diamond shaped. Both shapes will work; however, a diamond shape is a little more difficult to fit but will provide more gluing surface and blend with the grain better if the window is finished with varnish instead of paint. Be sure the dutchman is large enough to cover the affected area and thicker than the deterioration is deep. Slightly bevel all of the edges of the dutchman so that the widest face is the top. This will ensure a tight cork-like fit. Next, trace the outline of the dutchman's narrowest face on the existing member over the deterioration. Using the outline as a guide, carefully remove all of the deteriorated wood with a chisel. Test-fit the dutchman, and trim the hole until the dutchman bottoms out and fills the affected area entirely; the dutchman should be slightly higher than the existing material. Glue and clamp the dutchman in place. Once the glue has cured, use a chisel or hand plane to make the dutchman flush with the surrounding material. Hand sanding can be used for the final leveling of the two surfaces.

WPTC photo

Figure 13. Close-up of a dutchman repair (light-colored wood used to mend a window muntin).

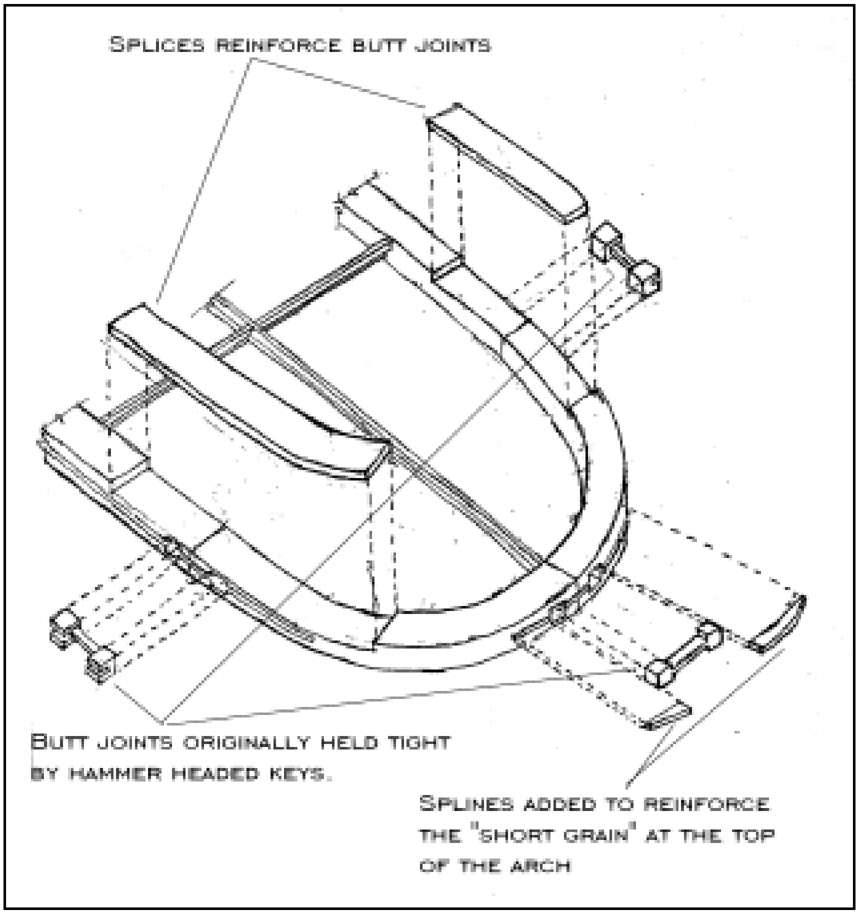


Figure 14. A wood window splice repair. (Illustration by Eric Ford, WPTC)

Epoxy, Fillers, and Consolidants

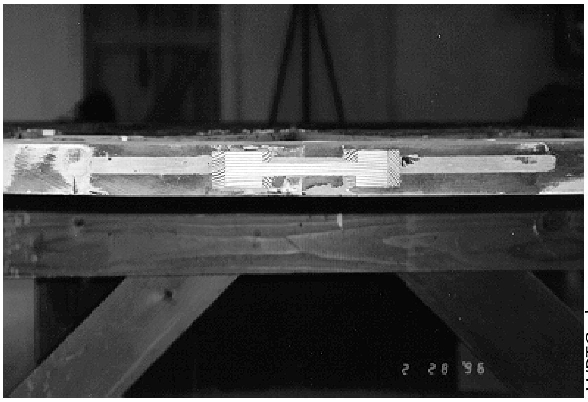
NOTE ABOUT EPOXY, FILLERS, AND CONSOLIDANTS: Epoxy treatments are irreversible, may not be approved for National Historic Landmark structures, and should be used only after a careful study has been made of more traditional repair technologies such as splicing and dutchmen. Some epoxy, filler, and consolidant treatments require training in the application of the system. Individuals not familiar with the use, effectiveness, and results of this technology should be trained in its use before field application.

Wood Windows

Repair of deteriorated wood sash and frame members is possible where there has been loss of material. It should be considered a primary option when joints have not twisted or warped, as when the surfaces of sills, lower portions of the frame, and bottom rails of sash have become eroded but have not cracked or split. Filling and consolidation of most frame members is performed in place, while sash consolidation is usually done in a shop.

When only wood surfaces are eroded, voids can be eliminated by applying a paste or putty filler. Apply fillers after the wood has dried and has been treated with a fungicide and a solution of boiled linseed oil.

In cases where a limited amount of rot has progressed well into the substrate, interior voids are filled in by saturating the wood with a penetrating epoxy consolidant formulated for wood. Surface voids, as well as decayed or missing ends near joints, are then filled or built up with an epoxy compound. When sash are in such poor



WPTC photo

Figure 15. This window sash frame was repaired with traditional (replacement wood hammerhead key) and modern epoxy filler (material to left and right of the hammer head key) techniques.

condition that they require consolidation, puttying and painting are typically also needed. Moreover, the joints connecting stiles and rails are likely to have become loose. After the glass and paint in affected areas have been removed, the sash is placed in a jig on a horizontal surface. Separated corners should first be repaired by pulling the joints together with a pipe clamp, drilling holes through adjacent stiles and rails, and securing each joint with a blind dowel. Rotted, missing, or eroded sections are then treated with the saturating epoxy, allowed to cure, and resurfaced with the epoxy paste. Surfaces are then sanded and painted as required.

Splicing and Bending Metal Window Parts

Damaged or severely corroded metal window sections can be removed and matching sections welded into place. Some rolled steel window stock is still manufactured or can be located in architectural salvage yards. Depending on the extent of deterioration, this repair can be done *in situ* or the sash may be removed and repaired in a shop. Because special skills are required for this type of repair, a certified window repair contractor should be consulted.

Deformed windows can be reshaped by gently applying pressure in the right location. This process may take a few days to complete. Depending on the extent of deformation, this repair can be done *in situ* or the sash may be removed and repaired in a shop. Because special skills are required for this type of repair, a certified window repair contractor should be consulted.

Adjusting Hardware

Properly cleaned and adjusted hardware will greatly extend the operable life of wood or metal windows. For routine cleaning use fine steel wool or a fine brass-wire brush and a cleaning solvent. All moving parts should be lubricated with a noncorrosive lubricant.

Limited Replacement In Kind

Windows are character-defining features of the historic lighthouse. Replacement of existing historic sash, no matter its condition, is a last-resort treatment. Replacement is usually the most expensive alternative and results in total loss of historic fabric. Replacement may be considered only if the historic sash are missing or too deteriorated for repair techniques. This decision should be made by a preservation professional such as a historical architect, engineer, or facility manager trained in preservation.

If replacement windows are put in a historic lighthouse, they should match the characteristics of the historic sash: number and size of lights, muntin width and profile, stile and rail dimensions and profiles, setback in window opening, and window-frame size and profile. For more information refer to NPS *Preservation Briefs: 9, 13, 16, 17, and 18*.

Use the following as a guide when considering window replacement:

- Always keep replacement to a minimum. Where sash replacement is called for, attempt to retain the window frame, hardware, and trim.

- Replacement may be the only feasible option when substantial structural damage to a window has occurred. Choose a replacement window with particular care. Ideally the new window should be an exact match of the old one. If this is not possible, carefully consider all of the window's characteristics, both interior and exterior, and its importance in the facade, when selecting a replacement.
- When a window is deteriorated to the point where it is no longer weathertight, the opening may be temporarily blocked in a manner which does not damage the historic window features. Reference the previous mothballing section for sensitive window blocking methods designed for historic windows.

For more information on the replacement of lighthouse windows refer to Part V., **Beyond Basic Preservation**.

Historic Lighthouse Preservation:

DOORS

WPTC photo

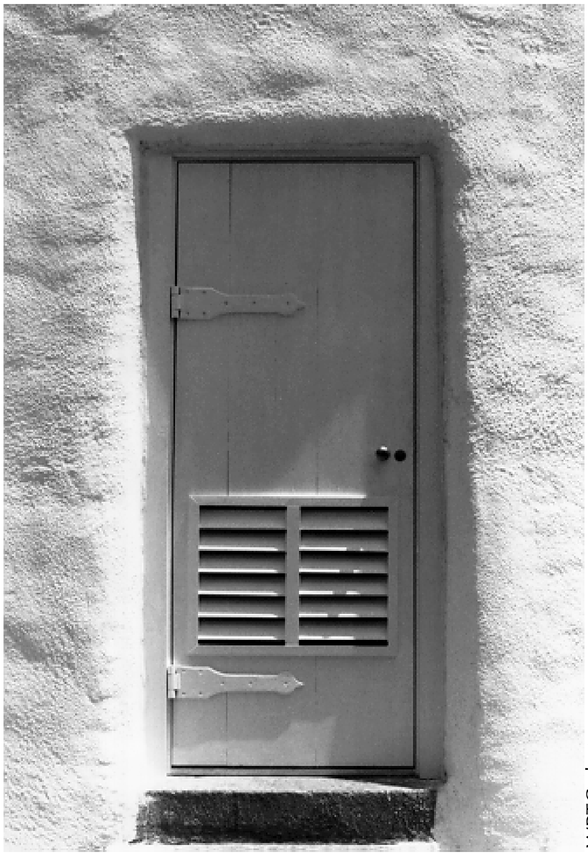
Figure 1. Close-up of large, double-leaf, wood-frame and panel doors at the Cape Henry Lighthouse (second tower), Fort Story, Virginia.

Tower exterior doors were quite often the focus of historic lighthouses. Together with their functional and decorative features such as steps, balustrades, pilasters, and architrave (trim or molding which surrounds the door opening), they can be extremely important in defining the overall character of a lighthouse. Usually entrances were integral components of a historic lighthouse's stylistic design and featured hallmark elements that defined the architectural style upon which the ornament of the structure was based. For example, entrances may be detailed with large raised panel doors trimmed with masonry or cast-iron pediments and pilasters which were associated with neoclassical architecture of the late 19th and early 20th centuries. The detailing may not be so grandiose but rather simple and utilitarian, such as the plain non-trimmed masonry openings fitted with vertical plank doors associated with the lighthouses built before the Civil War.

The primary cause of lighthouse door deterioration is moisture penetration of the various components by rain driven against and into doors, standing water on sills, and interior condensation. In a marine environment, deterioration caused by moisture penetration is exacerbated by extended periods of damp weather, which prevent the door and its components from drying out, thereby encouraging expansion

WPTC photo

Figure 2. View of the neoclassical doorway at the Ponce De Leon Inlet Lighthouse, Florida.



WPTC photo

Figure 3. View of the simple pre-Civil-War-style replacement plank door at the Ocracoke Lighthouse, North Carolina.

WPTC photo

Figure 4. View of gothic revival style entrance at Piedras Blancas Lighthouse, California.

and rot. Other factors that contribute to door deterioration are poor design, vandalism, insect/fungal attack, settlement over time, paint buildup, and deferred maintenance. This chapter will concentrate on the operational door components. (For information concerning the door surrounds and associated features refer to the **Masonry**, **Iron**, and **Wood** sections of this handbook.) This text is concerned with the preservation of historic lighthouse doors and their role in preserving the integrity of historic lighthouse. For more information on designs for recreating missing lighthouse doors, refer to Part V., **Beyond Basic Preservation**.

Door Types

A variety of door types were used in historic lighthouse construction. The following is a brief discussion of common historic lighthouse door types.

- ***Wood plank door:*** A door of one or two leaves that is constructed of two layers of tongue and groove wood planks that run vertically on the exterior side of the door, and typically run horizontally or diagonally on the interior. The planks are typically fastened by clinch nailing (nails that are driven through the outside of the door and bent over on the inside). The door is usually reinforced with horizontal 'battens' at the hinge locations: a diagonal batten may run from the top batten to the bottom batten. Such a door is typically hung on strap hinges; however, butt hinges may have been used. This construction method is used to limit the exposure of the end grain in the boards to the top and bottom of the door.
- ***Wood-framed panel door:*** A door of one or two leaves, constructed of a frame that is comprised of vertical stiles and horizontal rails connected by mortise and tenon joints; the openings in the frame are filled with flat or

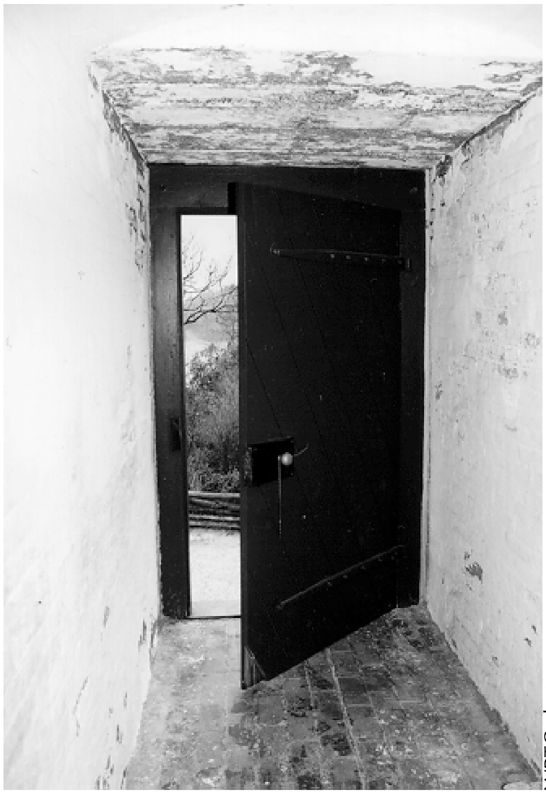


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Figure 5. View of the large, single-leaf, wood-plank door at the Cape Henry Lighthouse (first tower), Fort Story, Virginia.

WPTC photo

Figure 6. Close-up of the neoclassical, double-leaf, sheet-iron door at the Cape Charles Lighthouse, Smith Island, Virginia.

WPTC photo

Figure 7. Another variation on the double-leaf, sheet-iron door configuration at the Cape Canaveral Lighthouse, Florida.

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Figure 8. An example of a typical watertight 'ship' style door at Los Angeles Harbor Lighthouse, California.

raised panels. This construction method allows the exposure of the wood end grain only at the top and bottom of the stiles.

- ***Sheet iron or steel door:*** A door of one or two leaves, typically constructed of a single sheet of steel or iron that is reinforced along its perimeter with angle steel or iron, either riveted or welded to the sheet. The door is typically hung on strap or butt hinges that are either riveted or welded to the sheet.
- ***Watertight steel 'ship' style door:*** This door type was predominantly used in lighthouses that were located in wave-swept locations in open water and on the ends of breakwaters. The door is secured by multiple quick-action dogs that are actuated by an interior hand wheel.

Inspection and Evaluation

The first step to repairing historic doors is a thorough inspection of each door unit. Poor design, moisture, vandalism, insect attack, and lack of maintenance contribute to both metal and wood door deterioration. Of these factors, moisture is the primary factor in wood decay and metal corrosion. The following are some common problems to look for when inspecting doors for deterioration. (For more information on the deterioration of wood and metal refer to the **Wood** and **Iron** sections of this handbook.)

Inspection Chart for Lighthouse Doors

Look For:	*Possible Problems:*
Wood Doors	
Look for areas of paint failure and wood deterioration	Failing paint may indicate the wood is in poor condition and in need of repair. Wood is frequently in sound condition, however, beneath unsightly paint. After noting areas of paint failure, inspect the condition of the wood. Use an ice pick or an awl to test wood for soundness in an inconspicuous location. Pry up a small section of the wood. Sound wood will separate in long fibrous splinters. Decayed wood will lift up in short irregular pieces because of the breakdown of fiber strength. Plank doors are especially susceptible to wicking moisture along their bottom edge where the end grain is exposed. The lower ends of the stiles of a frame-and-panel door are especially susceptible to wicking moisture through the end grain. If deterioration has begun from within the wood member and the core is badly decayed, the visible surface may appear to be sound wood. Pressure on a probe can force through an apparently sound outer layer to penetrate deeply into decayed wood. This technique is especially useful for checking sills where visual access to the underside is restricted.

Look For:	*Possible Problems:*
Metal Doors	
Look for areas of paint failure	This may indicate the paint is at the end of its effective life span. Damage caused by bending will make the less flexible paint fracture and 'pop' off the door frame.
Look for areas of corrosion on all surfaces of the door leaf, frame, sub-frame (if visible), and hardware	This may indicate a moisture infiltration problem. Corrosion, typically in the form of rust, will occur along the bottom edge of the door leaf.
Look for bowing or misalignment of door leaves	Deformation could be the result of misuse/abuse or corroding components that have been deformed by rust-jacking or have simply deteriorated. Bowing or misalignment will more than likely prevent the door from being weathertight.
Both Door Types	
Check for gaps or cracks in the joint between the door frame and the lighthouse wall	Cracks or gaps are possible water infiltration points.
Examine the sill for a downward slope which allows water to drain	Without a downward slope, water will collect under the door causing deterioration or may run into the lighthouse causing deterioration of interior features.
Examine all flashing to ensure that water is directed away from the lighthouse and door opening	Improperly installed flashing may collect water or direct water into the lighthouse, causing premature deterioration of the lighthouse door, door frame, or interior features.
Check the moving parts of the doors	Bound or tight operating doors may simply be painted shut or may be stuck because of deteriorating frame members or bowed leaves, or may be bound by corroded hardware.
Inspect door units for water entering around the edges of the frame	The joints or seams should be caulked to eliminate water infiltration. Check the weather seal for cracked, loose, or missing sections.

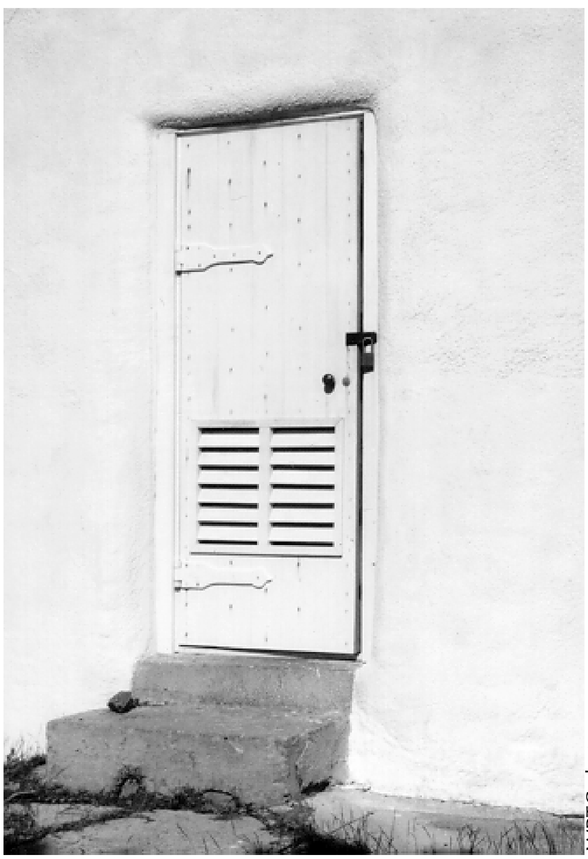
PRESERVATION TREATMENTS

Doors reflect a period and style as well as provide security for a lighthouse. During any preservation treatment both of these functions should be maximized. Because of character-defining nature of the door and its surrounding trim, all treatments should use the gentlest means possible. All replacement materials should be of the highest quality and able to withstand a harsh marine environment.

Many of the maintenance and repair techniques described in this text, particularly those relating to cleaning and painting, are potentially dangerous and should be carried out only by experienced and qualified workmen using protective equipment suitable to the task. In many cases, it is best to involve a historical architect or building conservator to assess the condition of the door and its components and prepare contract documents for the required treatment.

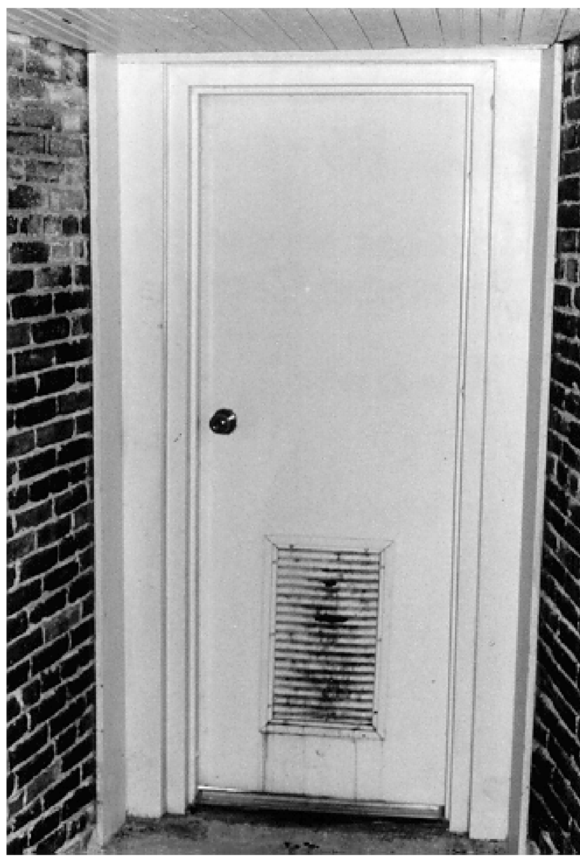
Protection and Stabilization (Mothballing)

Before any preservation treatment is performed, the lighthouse door and its surroundings should be thoroughly inspected using the information in the preceding section as a guide. From these findings, a preservation treatment plan can be developed.



WPTC photo

Figure 9. View of the Ocracoke Lighthouse five years after replacement; note rust streaks from nails. This condition indicates the paint coating has degraded to the point where moisture has permeated the surface.



WPTC photo

Figure 10. Interior view of the modern metal door at the Ocracoke Lighthouse before its replacement; corrosion like this should be removed and the affected areas treated with a rust-inhibiting coating system.

When mothballing wood or steel doors, protection of historic fabric and security should be the primary goals. Treatments for the protection of wood and iron lighthouse components during the mothballing period are covered in the sections on **Wood** and **Iron**; therefore they will not be reiterated in this section. This section will concentrate on lighthouse security during the mothballing period.

Security

Lighthouses which have been mothballed usually have the openings on the lower level covered to reinforce entry points. The following are general guidelines to consider when securing doors during the mothballing period.

- Make all repairs to the door and frame to prevent further damage during the mothballing period. (Refer to the following repair treatment for more information.)
- When securing a door during the mothballing period, the most important factors to consider are ease of authorized entry and retention of character-defining features. The method of installation should not result in damage to the door, the opening, door jamb, or frame. If parts of the door must be removed to secure the opening, all parts should be labeled and stored in the lighthouse if possible.

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Figure 11. These louvered doors have been installed at Point Sur Light Station for security and ventilation. Note the baffles on the exterior and the screened louvers on the interior.

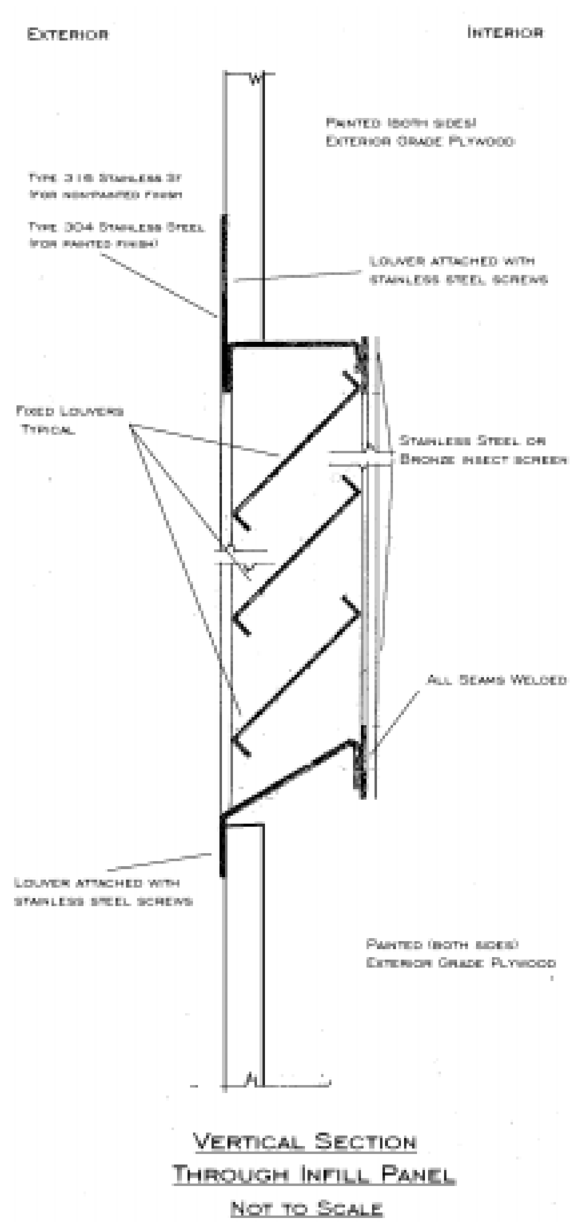
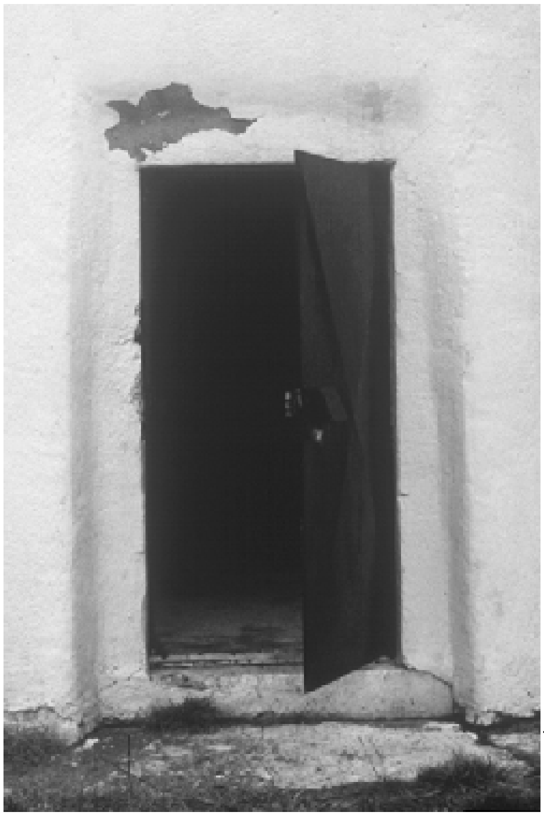


Figure 12. Typical detailing of a 'storm proof' louver for temporary lighthouse doors. (WPTC image adapted from drawing from USCG-CEU Oakland Archives)



WPTC photo

Figure 13. Site-built steel door at the Turkey Point Lighthouse; this solution was chosen because of the remote location and repeated break-ins. Note exterior stiffeners and shroud over the hasp and lock.

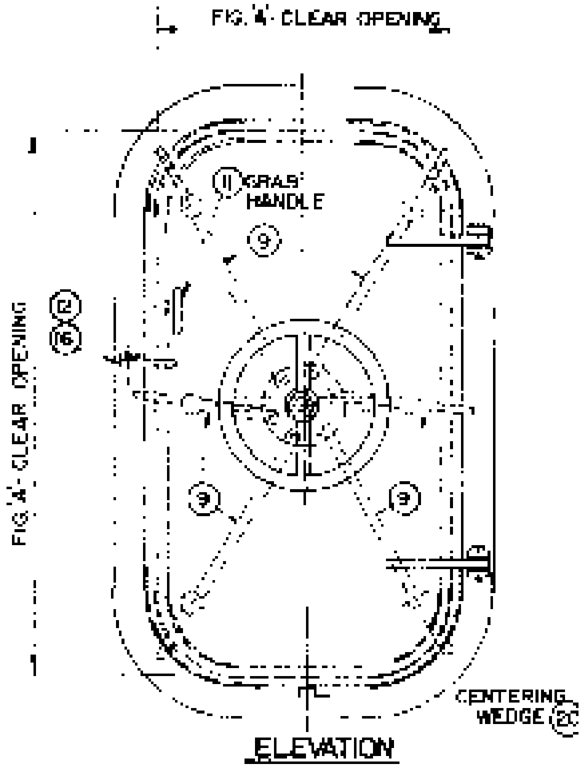
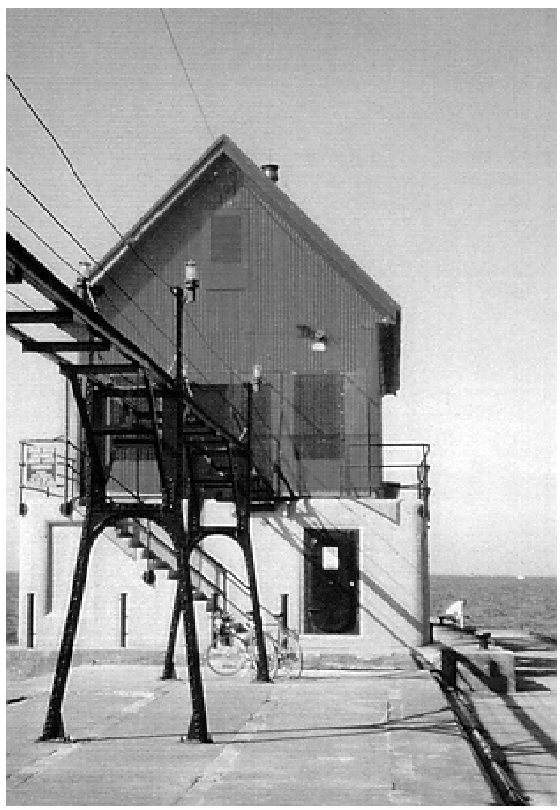


Figure 14. A shop drawing depicting the parts of the watertight 'ship' style door. (Drawing courtesy of Cen-Tex Marine Fabricators)

For situations where the door has been severely damaged beyond repair or removed by vandals or has deteriorated extensively because of neglect, a temporary, reversible security door should be installed. The following are two types of temporary steel security doors:

Site-built, fabricated steel door: This door consists of a steel 'C' channel frame set into the existing opening that is lag-bolted to the existing door frame. On the outside of this frame, the door leaf is connected by welding the hinges to both the frame and door leaf. The door leaf should overlap the opposite door frame to facilitate the installation of an eye that will pass through a slot in the door leaf to facilitate a lock. A steel shroud big enough to facilitate lock operation with a key, but prevent bolt cutters from reaching the lock, should be welded over top of the eye slot. If the lighthouse is not in an area that is to being wave swept (i.e., if the lighthouse is located on a breakwater or pier), the door should be fitted with screened louvers that are approximately 25 percent of the total door area. The louvers



USCG Group Grand Haven

Figure 15. View of watertight 'ship' style door installation on the Grand Haven South Pierhead Front Range Light, Grand Haven, Michigan.

should be constructed from the same gage steel as the rest of the door.

Watertight steel 'ship' style door: This type of door consists of a prefabricated 'ship' style door. This door system can be fitted much the same way as the site-built door. A steel 'C' channel frame should be bolted to the door opening; the prefabricated watertight door can then be welded to the frame. The prefabricated door should have six quick-action dogs, an interior hand wheel, and a flush exterior-socket-locking mechanism that can be actuated with a mating 'T' wrench. The hinge pin caps should be welded to prevent disassembly. This door will provide a weathertight, vandal-proof access that can be removed after the mothballing period.

WARNING: When installing either of these door types, the treatment should be completely reversible and not damage or cause future damage to existing historic fabric.

Repair

When repairing wood or steel doors, protection and retention of historic fabric should be the primary goal. Here are a few general guidelines for historic lighthouse door repair; refer to the aforementioned sections for more information.

- Repair doorways by reinforcing the historic materials. Repair will also generally include the limited replacement in kind—or with compatible substitute material—of those extensively deteriorated or missing parts of repeated features such as pilasters, architrave, sidelights, door leaves, and stairs where there are surviving prototypes.
- Do not remove or radically change a door that is important in defining the overall historic character of the lighthouse. Do not strip entrances of historic material such as wood, cast iron, and brick.

Door Hardware

Historic lighthouse door hardware is not only functional but also significant in defining the character of the historic door. Lighthouse door hardware such as door knobs, hinges, keyhole escutcheons, and even strike plates were often decoratively detailed with motifs of the architectural style of the lighthouse. When preserving historic lighthouse doors, the existing hardware should be retained. When repairs are made to the door, the hardware should be removed for protection or protected in place to avoid any damage that may be incurred during the repair process. If the hardware is removed, label each piece to

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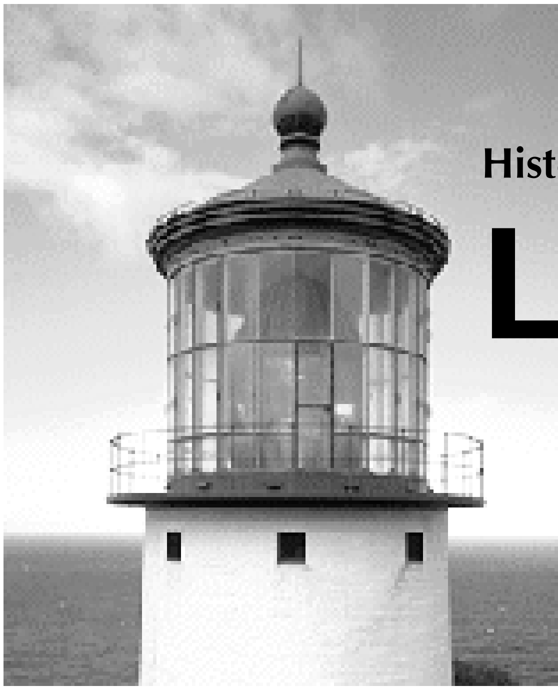
Figures 16 and 17. Examples of decorative door hardware found in late 19th-century lighthouses.

ensure that it is reinstalled in its proper location.

Limited Replacement In Kind

- Replace in-kind door components that are too deteriorated to repair—if the form and detailing are still evident—using the physical evidence as a model to reproduce the component. If using the same kind of material is not technically or economically feasible, then a compatible substitute material may be considered.



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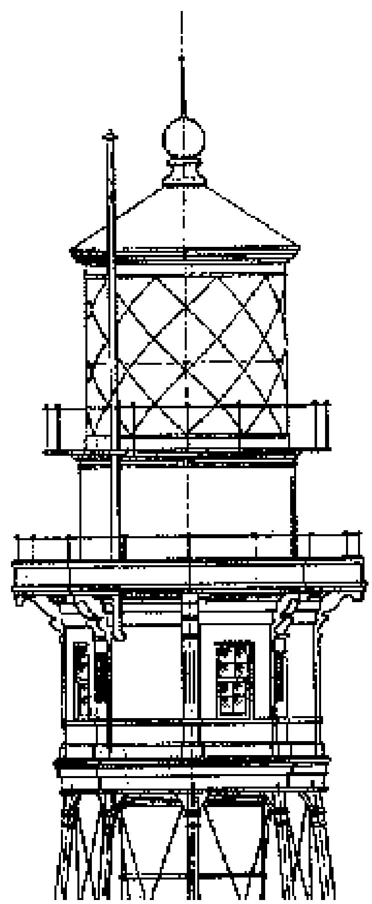
Historic Lighthouse Preservation:

LANTERN

Figure 1. Lantern housing hyper-radiant lens at Makapuu Lighthouse near Waimanalo on the Island of Oahu in Hawaii.

The primary purpose of the lantern is to provide a weathertight shelter for the lighting apparatus. The lantern also functions as the 'roof' for the tower. Lighthouse lanterns come in a wide variety of shapes and sizes; most lanterns have similar components and therefore, share similar problems. A typical lantern consists of a frame that supports the lantern glass and roof, in some cases a masonry or wood parapet wall, a lens apparatus, and interior and exterior hatches.

Despite the inherent durability of the lantern design and construction, deterioration caused by environment is still a constant threat. Improper maintenance or repair techniques can also accelerate deterioration; therefore, all treatment should be executed using the gentlest means possible. Character-defining features such as material type, size, profile; decorative brackets; lantern glass (almost always clear or red glass); decorative railing standards; etc., should all be examined. Whether the planned preservation treatment is mothballing or repair, a proper inspection and diagnosis



National Archives

Figure 2. Original construction drawing of the first-order Cape Fear Lighthouse showing the lantern above the service/watch room.

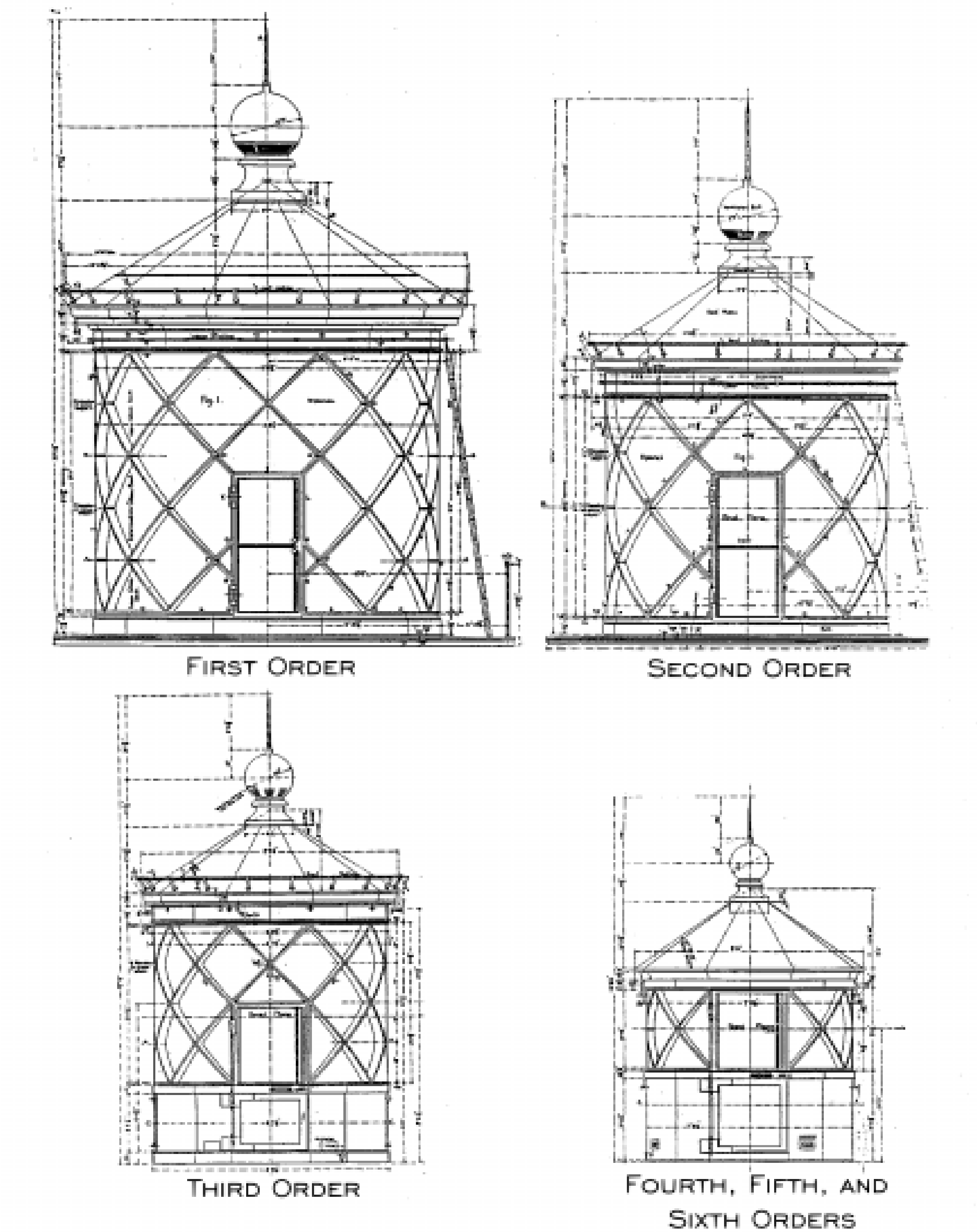


Figure 3. Illustration of the four standard lantern sizes used by the U.S. Lighthouse Establishment in the first half of the 20th century. Drawing assembled by WPTC from images dated 1898 and 1903 courtesy of USCG CEU Oakland.

WPTC photo

Figure 4. Close-up of the fourth-order lantern at Coquille River Lighthouse in Oregon.

WPTC photo

Figure 5. Close-up of the first-order lantern at Cape Canaveral in Florida.

should be performed in order to determine the most effective treatment solution.

For more information on replacing missing or severely deteriorated lantern components refer to Part V., **Beyond Basic Preservation**.

Lantern Construction

In order to withstand harsh weather conditions, the components of a typical lantern are made from a variety of materials and metals. The main support structure (including the floor), certain types of parapet walls, and the lens pedestal are typically made of cast iron for strength. The roof, ventilation ball, and lightening rod are typically made of copper, which can withstand severe weathering (and in the case of the lightning rod, can conduct electricity). The astragals and clamps that hold the lantern glass in place as well as grab handles are typically made of bronze which resists corrosion and is durable. Brass screws compatible with the bronze are typically used to attach the astragals to the lantern frame. If these parts corrode, damage to the lantern glass can result.

The variety of metals used in lantern construction creates the potential for galvanic corrosion. Various techniques were employed to prevent corrosion. An electrolyte such as water must be present for galvanic corrosion to occur, so joints were caulked with litharge to keep areas of contact between dissimilar metals dry. Litharge was used to protect iron lantern frames from bronze astragals. In other locations such as where the cast-iron lantern roof ‘rafters’ came in contact with the copper roof covering, an insulating barrier was used. When preservation treatments are performed on historic lanterns, these details should be maintained.

Interior features such as vent dampers and lens frame parts are typically made of brass for its durability, stability, and decorative qualities. Other interior finishes include beaded tongue-and-groove wood paneling or sheet iron on the parapet walls, and wood tongue-and-groove flooring. These finishes are typical in the smaller fourth- through sixth-order lanterns.

Special Conditions Associated with Historic Lantern Systems

A variety of special maintenance conditions can occur in a historic lantern system but may not occur in any other part of the lighthouse. (The treatment and prevention of these conditions are addressed under the repair treatment in this chapter.)

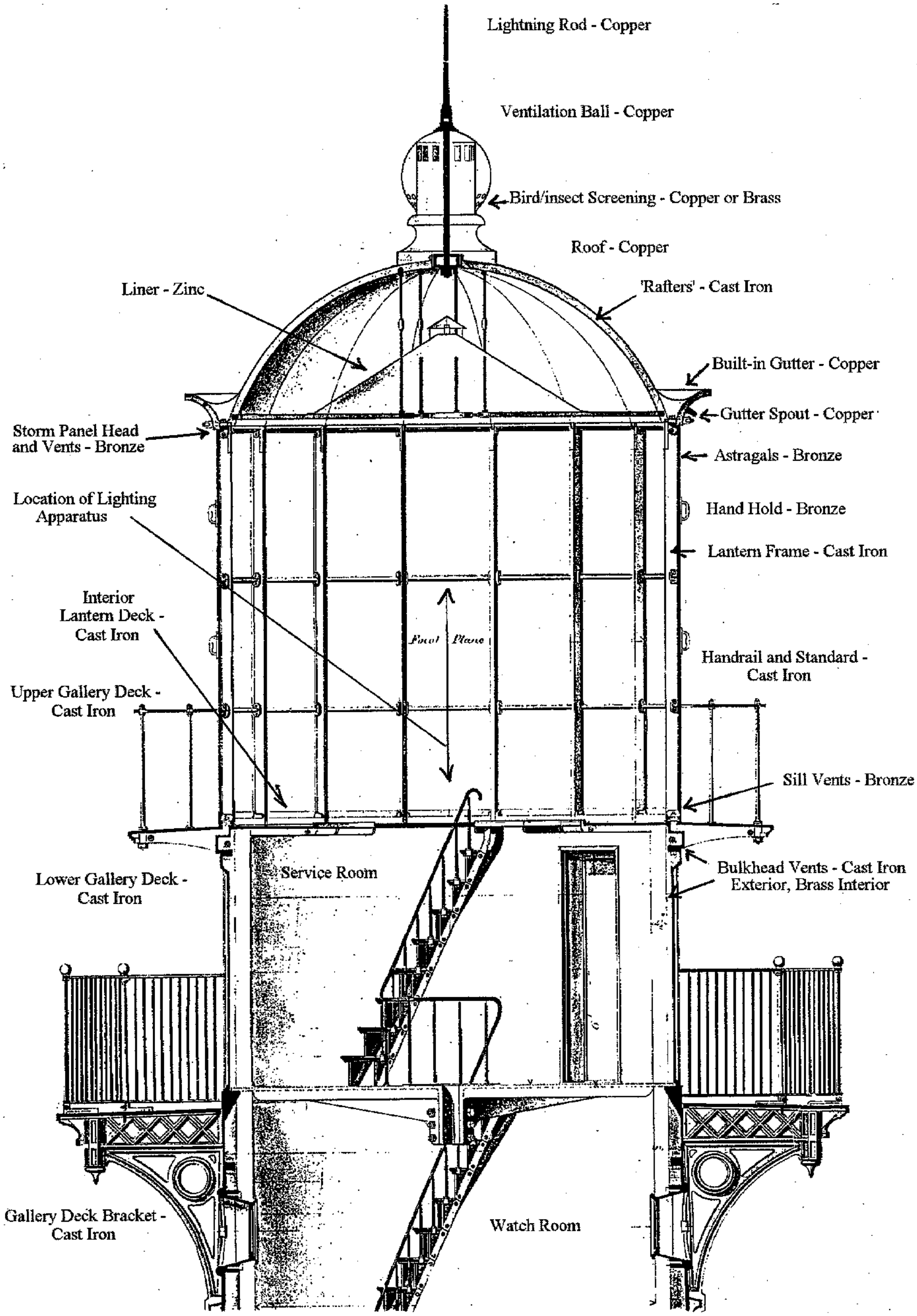


Figure 6. Diagram of a typical first-order lantern; the parts are similar to second- and third-order lights. (Diagram based on USLHS drawing in the National Archives)

Galvanic Corrosion

Galvanic corrosion is an electrochemical action that results when two dissimilar metals react together in the presence of an electrolyte, such as water containing salts or hydrogen ions. This type of corrosion is normally significant only between groups separated by lines in the Galvanic Series in Water table below; the effect is small between members of the same group. Galvanic corrosion is the result of a spontaneous flow of positive electric current from the more 'noble' metal to the more 'base' metal. The more 'base' metal then dissolves. The severity of the galvanic corrosion depends on the difference between the two metals, their relative surface areas, and time. If the more noble metal (higher position in electrochemical series) is much larger in area than the baser (or less noble) metal, the deterioration of the baser metal will be more rapid and severe. If the more noble metal is much smaller in area than the baser metal, the deterioration of the baser metal will be much less significant.

An example of an undesirable situation that permits galvanic attack is the use of steel or aluminum fasteners to hold together a copper-covered lantern roof. Since the more noble metal is in contact with a small area of a more base metal, galvanic attack would corrode away the fastener with nothing to hold the copper cover to the lantern should the coating system fail and allow water (the electrolyte) to facilitate the galvanic corrosion.

GALVANIC SERIES IN WATER, 20°C		
MORE NOBLE	GROUP I	Titanium Alloys Nickel Alloys Stainless Steels Silver
	GROUP II	Copper Alloys (Bronze/ Brass) Lead Alloys Tin Alloys
	GROUP III	Cast Iron Structural Steels
	GROUP IV	Zinc Alloys
	GROUP V	Aluminum Alloys
MORE BASE	GROUP VI	Magnesium Alloys

Source: USCG Fixed Aids to Navigation Maintenance, Commander, Ninth Coast Guard District, Cleveland Ohio, CCGDNINEINST MI6500.2. For more information on galvanic corrosion of metals, refer to *Metals in America's Buildings: Uses and Treatments* (U.S. Dept. of the Interior) or *Corrosion Handbook* by Herbert H. Uhlig (ed.), 11th ed. 1969.

Sea water is especially corrosive. Marine atmospheres and sea water contain several corrosive agents including chlorides and other salt particles which can be deposited on the surface of the metal. These corrosive agents can affect metals as far as 60 to 70 miles from the sea (depending on weather patterns). Metals immersed in water are also subject to corrosion by dissolved solids and gases, especially oxygen.

If this condition occurs all screws, bolts, nuts, welds, and fastenings of any kind should always be made from a more noble material than the remainder of the structure. (For more information concerning prevention of galvanic corrosion refer to the repair treatment in this section of the handbook.)

WPTC photo

Figure 7. The white chalky residue around the steel bolt heads on this aluminum deck is the by-product of the corrosion occurring at these connections.

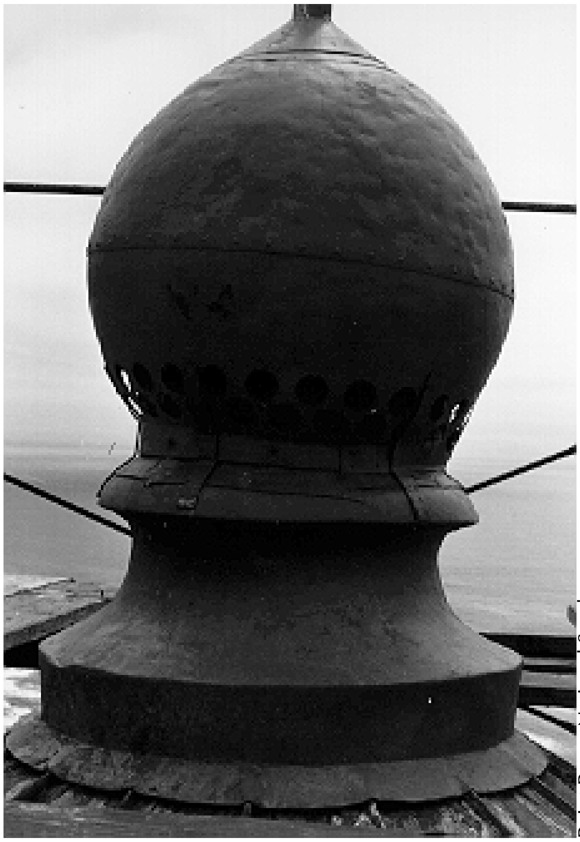
Rust-Jacking

Rust-jacking threatens any iron or steel component. In lantern glass, the condition can cause severe damage. When moisture enters the channel that retains the glass, the iron frame may begin to rust. As the iron rusts, it expands and in turn cracks the glass. This phenomenon can occur anywhere a ferrous metal (iron or steel, etc.) is in direct contact with another material. The pressure created by the exfoliating rust (iron oxide) may damage the adjacent material. (For more information concerning prevention of rust-jacking refer to the repair treatment in this section of the handbook.)

Ventilation

Nearly all, if not all, lanterns have a ventilation-ball vent located at the apex of their roofs which served as the primary vent for the fumes and smoke created by the oil-fired illuminant. Secondary vent locations varied by the size of the lantern: first- and second-order lanterns typically had vents located in the watch room area below the lantern and in the sill and head areas of the lantern glass; smaller third- through sixth-order lanterns had vents typically located in every other panel of the parapet wall.

All vents were baffled to prevent strong winds from blowing directly into the lantern and extinguishing the light. Air flow through the vents was also controlled by a variety of sliding registers and/or rotating dampers. While the illuminant was lit, vents located in the lantern opened to allow fresh air into the lantern; it would be heated by the flame and then rise out through the ventilation ball. This action created a draft that helped keep the lantern glass clear of condensation and maintain an ambient humidity level within the lantern. This ventilation was essential for the operation of the lantern as well as its preservation. (For more information on



Point Reyes National Seashore

Figure 8. Despite the fact that this first-order lantern ventilation ball has been repaired several times, it still provides adequate lantern ventilation.

WPTC photo

Figure 9. An example of a parapet-wall-mounted vent on a fourth-order lantern.

WPTC photo

Figure 10. Close-up of missing clamp bolts; these bolts should be replaced to keep this area weather tight.

lantern and lighthouse ventilation refer to the repair treatment in this section as well as the **Windows** section.)

Lantern Glass

Lantern glass is typically 3/8 inch thick. The glass plays two important roles in the lantern system. First, the glass should be clean and clear to allow the greatest amount of light transmission. Second, the glass has to withstand high winds, driving rain, and airborne material (i.e., sand, wave-tossed rocks, and birds). Proper installation care and replacement ensures that these demands are met. Refer to the repair treatment in this section for more information on lantern glass care and replacement.

Why Do Lanterns Deteriorate?

Lanterns are made from a variety of metals and materials. These materials are subject to a host of severe weather conditions. How successfully a lantern resists these pressures depends on how well it is designed and maintained. A well-built, well-maintained structure may withstand these forces indefinitely.

The leading causes of decay are:

- excessive moisture from leaking roofs and lantern glass, and condensation because of poor ventilation within the lantern itself all corrode iron components and provide the electrolyte that facilitates galvanic corrosion between dissimilar metals;
- corrosion of iron lantern glass frames which results in ‘rust-jacking’ that causes the glass to crack, thus providing a moisture infiltration point; or
- failed coating systems that no longer protect lantern components.

Secondary factors causing decay:

- abrasion by the wind and wind-born solids that accelerates deterioration by rapidly removing corroding or exfoliating material;
- mechanical damage due to ice, impact, or wind;
- damage caused by vandalism;
- chemical disintegration caused by pollutants in the atmosphere; or


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Figure 11. The water that has collected in this lantern sill is causing the iron lantern glass frame (the vertical members in the center of the photo) to rust and corrode.


WPTC photo

Figure 12. The glass in this lantern has been cracked by the rust-jacking that is occurring along the iron frame.


WPTC photo

Figure 13. The paint coating that once protected this lantern parapet wall has failed.

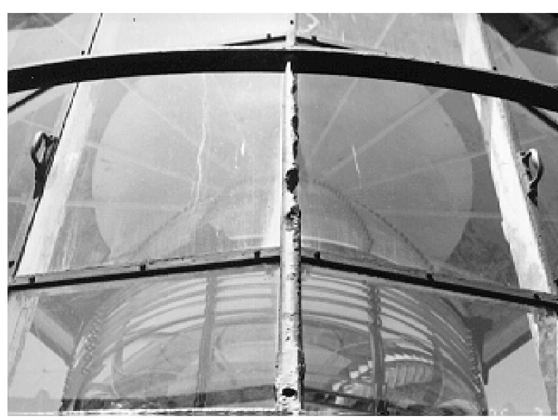
WPTC photo

Figure 14. Wind and airborne sand have accelerated the deterioration of this lantern gallery deck handrail

USCG Group Grand Haven, Michigan

Figure 15. Close-up of ice on St. Joseph North Pier Lighthouse causing damage to gallery deck and handrail.

WPTC photo

Figure 16. This lantern glass has been damaged by rock-throwing vandals. The resulting hole is allowing rain and insects to enter the lantern.

- damage caused by deterioration of the tower structure that supports the lantern.

Inspecting for Lantern Problems

In order to develop an effective treatment plan for lantern problems, an in-depth inspection should be made of the lantern and its immediate surroundings. The following chart is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Lighthouse Lanterns	
THE SITE	
Environment	
Look For:	*Possible Problems:*
General climatic conditions, including average temperatures, wind speeds and directions, humidity levels, and average snow and ice accumulation	Severe conditions can lead to lantern deterioration caused by excessive heat build-up, moisture condensation, or snow or ice load that could literally tear exterior decks off of the lantern.
Number of freeze-thaw cycles	Severe cycles can produce damage from frost action within masonry parapet walls.
Location near sea	Salt in the air can lead to accelerated corrosion of metal components.
Acid rain in the region or from nearby industry	Acid rain can act as an electrolyte, which may facilitate galvanic corrosion between dissimilar metals.

Look For:	*Possible Problems:*
Proximity to a major road highway or railroad	Vibrations are harmful to mortar joints in masonry parapet walls; cyclic vibrations may cause failure caused by fatigue in metal components.
Location in the flood plain of a river, lake, or sea	Floodwaters can bring damaging moisture to foundations and walls. If differential settlement results, the lantern may be damaged by the mechanical action.
Exposed or sheltered sections of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration.
THE LIGHTHOUSE	
Overall Condition	
General state of maintenance and repair	A well-maintained lighthouse should require fewer major lantern repairs.
Evidence of previous fire or flooding	Such damage may have weakened structure members or caused excessive moisture within the lighthouse tower and lantern, thus causing or accelerating corrosion.
Signs of settlement	Uneven settlement can crack foundations or walls or result in sloped or wavy mortar joints. If differential settlement results, the lantern may be damaged by the mechanical action.
Lantern	
General condition	A well-maintained lantern should require fewer major repairs. A leaking lantern may leave stains under the gallery deck on the exterior of the lighthouse as well as streaks on the interior walls of the tower spaces below. This moisture can accelerate corrosion of lantern components.
Roof drains (usually associated with larger first-order lights) and roof covering	Clogged roof drains can hold water in the built-in guttering system and accelerate deterioration of the roof covering. Small holes in the roof covering can be moisture-infiltration points. This moisture can accelerate corrosion of lantern components.
Gallery decks, copings, and structural seams	Gaps in gallery decking (cast-iron plate, flat-seam metal, stone, concrete, etc.) and tower wall copings (stone, metal, concrete) can allow water to penetrate into the interior cavities of the tower wall, thus accelerating the deterioration of the tower.

Look For:	*Possible Problems:*
Lantern vents and humidity level within the lantern	Non-functioning lantern vents can prohibit the release of humid air from within the tower. The water vapor will ultimately condense on the surfaces inside the tower and lantern. The excessive moisture will promote mold and mildew growth and accelerate corrosion.
Condition of storm panels	Cracks and holes in the storm panels can provide an infiltration point for moisture into the lantern.
Condition of storm panel glazing compound	If the glazing compound is cracked or missing, water can enter the frame channel and cause possible rust-jacking to occur along the perimeter of the storm panel. The bottom edge of the storm panels is especially susceptible to this condition.
Lantern Coatings	
Paint; type of paint	Various paint types require different treatment methods and safety precautions.
Blistering, flaking, and peeling paint	These conditions indicate the paint is at or near the end of its effective life span.
Lantern Parapet Walls	
Construction method—iron, masonry, wood—solid or cavity	Knowing how a parapet wall is constructed will help in analyzing problems and selecting appropriate treatments.
Condition of seams between wall construction materials	In wood parapet walls the seams between sheathing boards must be watertight and all end-grain must be protected from moisture contact. In iron parapet walls the seams between panels must be completely watertight to prohibit water from entering the interior wall cavity and causing the iron to corrode from the inside out.
Evidence that parts of the parapet wall were repaired or modified	Inappropriate repairs may be the source of deterioration.
Tower Interior	
Cracked plaster, signs of patching, floors or landings askew	These are signs of lighthouse settlement. Differential settlement can cause mechanical damage to the lantern.
Interior moisture levels	High interior moisture levels may cause accelerated deterioration of lantern components.

PRESERVATION TREATMENTS

WARNING: Many of the maintenance and repair techniques described in this text, particularly those relating to cleaning and painting, are potentially dangerous and should be carried out only by experienced and qualified workmen using protective equipment suitable to the task.

Lantern features such as gallery deck brackets, handrails, lantern frame structures, decorative panels cast into parapet walls, as well as textured finished surfaces such as raised-diamond-pattern non-skid surfaces, lantern glass, roof shape/material, etc., are important in defining the historic character of the lighthouse. Character-defining features should be retained during any treatment.

Protection and Stabilization (Mothballing)

Before mothballing, a thorough inspection and diagnosis should be performed, using the inspection chart in the preceding section as a guide. Keep in mind that a lighthouse lantern is designed to be an active part of the lighthouse. The light keeper gave the lantern daily maintenance attention. When mothballing a lighthouse lantern, this regimen of care and attention cannot be continued. As a substitute for daily attention and care, a comprehensive mothballing plan may be prepared using the following guidelines.

Weatherization

When a lighthouse lantern is mothballed, it is essential that the exterior envelope be completely weathertight. To prevent moisture penetration, be sure the following infiltration points are weathertight or functioning properly:

- ***Lantern roof***: The lantern roof must be made weather tight during the mothballing period. Any metal roofing patches should be made with like-kind materials soldered in place. In the case of excessive deterioration, a new roof which matches the original in material and configuration should be considered as a protective measure during the mothballed period. (For more information refer to the discussion on roofing later in this section.)
- ***Lantern glass***: Lantern glass and frames must be weathertight. Damaged glass can be temporarily repaired using sheet metal and caulking. Caulk patches should be used only as a temporary fix and not relied on during the mothballing period. To minimize water infiltration, damaged glass should be replaced as soon as possible, using glass because of its superior weathering qualities. (For more information on lantern glass replacement refer to the repair treatment later in this section.)

WPTC photo

Figure 17. Roof vents such as these should be inspected for leaks and maintained during the mothballing period. This shroud-style vent allows air to pass while preventing rain from entering.

- ***Built-in guttering systems***: All rain water guttering systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. All holes and non-functioning gutter system components should be repaired. Holes in sheet-metal, built-in gutters, should be properly soldered to ensure the soundness of the repair (see Figure 18). Caulking should be used only for temporary repairs until a proper soldered repair can be made. (For more information refer to the lantern roof discussion later in this section.)

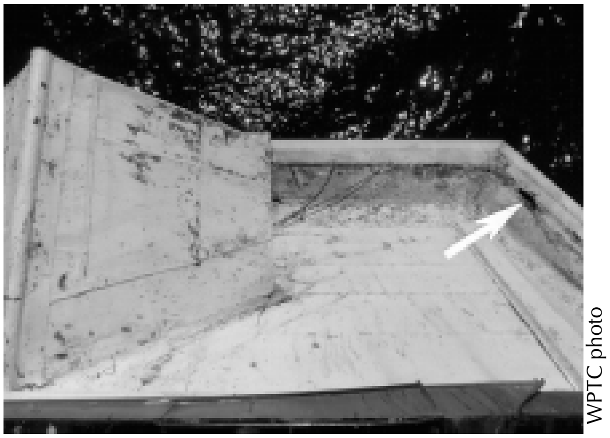

Figure 18. View of built-in gutter on a caisson lighthouse; arrow indicates fist-size hole. This condition must be treated before mothballing.

- ***Gallery decks****:* In most lighthouses gallery decks are cast-iron, sheet-metal-covered wood, stone, or concrete. These decks are generally laid directly on top of the wall structure and act literally as the roof for portions of the lighthouse below. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior of the lighthouse or lantern. (Refer to the following repair treatment in this section for more information concerning the weatherproofing of gallery decks.)
- ***Parapet hatch, service room door:*** Regardless of the size of the lantern, it will have a hatch or door of some form in the lantern itself or in the service room that provides access to the exterior of the lantern. This opening must be made weathertight. To achieve this, the latch and hinges must be lubricated and in working order. The opening should be fitted with a gasket material such as neoprene that is both readily available and long lasting. The flashing that protects the door opening must also be in working order so that it diverts water away from the door or hatch opening.
- ***Service room windows:*** For more information on window treatment, refer to the **Windows** section.
- ***Protective coatings:*** As a protective measure and for daymark purposes, lanterns were

Figure 19. The repair made to this stone gallery deck has begun to deteriorate; moisture penetration is occurring. This condition should be addressed before mothballing.

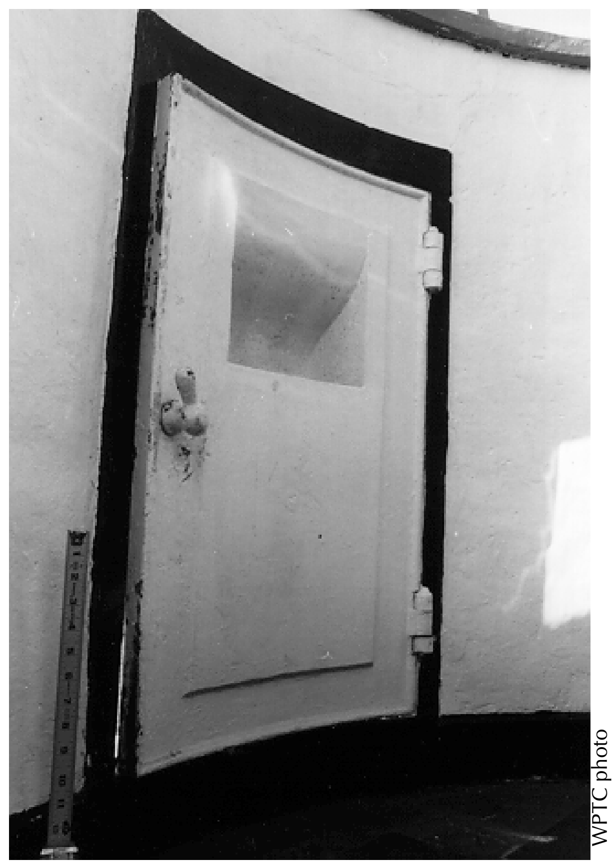

Figure 20. Close-up of a vented parapet hatch in a fourth-order lantern. The hatch should have a good seal and still remain operable. The built-in vent should also be kept open to maximize ventilation of the lantern and tower.

historically painted. As part of a mothballing treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color. Ultimately, as part of a mothballing treatment, the entire lantern should have all loose and flaking paint removed and a new coating applied (if the lantern was historically painted) according to the manufacturer's specifications. This action will result in a coating system that will require minimal service during the mothballed period. (For more information refer to the discussion on paint and coating systems in the **Iron** section. For more information on lantern coatings refer to the Anacapa Island Lighthouse case study in Part V., **Beyond Basic Preservation**.)

Stabilization

Because the lighthouse lantern plays a role for protecting both the lighthouse and the illuminant, the structure should be sound during the mothballing period. Stabilization treatments should be reversible and fail-safe; effective methods include: installation of intermediary bracing and shoring that supports compromised members; 'sistering' of wood or steel members to compromised members to help carry the load. Treatments should not interfere with the daily operation of the light. With this in mind, it would be advantageous to repair any structural deficiency before mothballing the lighthouse. A structural engineer or historical architect should be consulted for a proper stabilization or repair treatment plan.

Ventilation

During any preservation treatment the vents should remain operable to allow the maximum amount of air flow through the lantern. To prevent pest infiltration, the exterior openings of the vents should be screened with fine brass or stainless steel screen. When vents are kept open, natural convection caused by sunlight heating the air within the lantern will create a chimney effect as the warm air rises that will help maintain an ambient temperature and humidity within the lantern. The chimney effect will also aid in the ventilation of the

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Figure 21. The diagonal tension rods in this empty lantern were installed to brace the lantern against lateral loading caused by high winds.

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Figure 22. Close-up of sill vents in a first-order lantern. The vents should be kept open during the mothballing period to maximize lantern and tower ventilation.

WPTC photo

Figure 23. As part of the lantern mothballing treatment the lantern glass sill vents should be kept open (except in extremely damp climates) to allow for the free flow of air through the lantern.

entire lighthouse. (For more information on lighthouse ventilation refer to the **Windows** and **Interiors** ventilation sections.)

Fire Protection

Despite the fact that lanterns are constructed of predominantly noncombustible materials, fire is still a threat to irreplaceable combustible components of the lantern. For guidance on these issues, refer to "Fire Prevention and Protection Objectives" under **Related Activities** in Part V.

Repair

> *WARNING: Many of the maintenance and repair techniques described in this text, particularly those relating to cleaning and painting, are potentially dangerous and should be carried out only by experienced and qualified workmen using protective equipment suitable to the task.*

A thorough inspection and diagnoses should be performed using the earlier inspection chart as a guide, and a preservation treatment plan developed. If the lighthouse is still an active aid to navigation, the preservation plan should include repair treatments to ensure the effective operation of the lighthouse and lantern in the future. The following are general guidelines for repairing a lighthouse lantern.

Galvanic Corrosion

As mentioned previously, galvanic corrosion is an electrochemical action that results when two dissimilar metals react together in the presence of an electrolyte, such as water containing salts or hydrogen ions. This type of corrosion is normally only significant between groups separated by lines shown in the Galvanic Series in Water Table in the Special Conditions Associated with Historic Lantern Systems found earlier in this section. Galvanic corrosion is the result of a spontaneous flow of positive electric current from the more 'noble' metal to the more 'base' metal. The severity of the galvanic corrosion depends on the difference between the two metals, their relative surface areas, and time.

Methods of Galvanic Corrosion Prevention:

- When repairing damage that has been caused by galvanic corrosion, first clean all surfaces of corrosion; second, identify the condition that caused the corrosion to form; third, address the problem with one of the prevention methods below.
- Ensure that the electrolyte, water, is not allowed to penetrate joints between dissimilar metals. The joints can be sealed using the existing detailing (i.e., flashing, profiles of members) combined with modern caulks and sealants.
- Use non-reacting stainless steel or brass fasteners when joining two dissimilar metals that have a potential for galvanic reaction. Brass screws are preferable to stainless steel. The hardness of the stainless steel screws may damage the receiving threads if not properly aligned. If the threads have been damaged, they will need to be tapped for a slightly larger screw.
- Always apply an anti-seize coating to fasteners before inserting them. This will prevent corrosion from forming in the hole which could cause the fastener to break off.
- Provide a barrier between the dissimilar metals. This barrier can be simply a coating of a corrosion-inhibiting paint that is rated as an electric insulator. If the original detailing provided for a gasket-type barrier, a chromate-impregnated wool, felt tape, or a commercially available neoprene gasket material may used.
- All welds should be made from a more noble material than the remainder of the structure.

Rust-Jacking

Rust-jacking is a deterioration condition associated with any iron or steel component. The 'jacking' is the result of the chemical change that takes place when iron corrodes or rusts. As the iron rusts, it changes from iron to iron oxide; this change is the result of the oxygen carried in water combining with the iron. The resulting iron oxide takes up more volume than the iron. The force of this expansion is strong enough to crack glass and force steel components apart. Lantern glass in this condition can cause severe damage. When moisture enters the channel that retains the glass, the iron frame may begin to rust. As the iron rusts, it expands and in turn cracks the glass. (For information concerning the repair of damaged or deteriorated iron, refer to the **Iron** section.)

Methods for Preventing Rust-Jacking

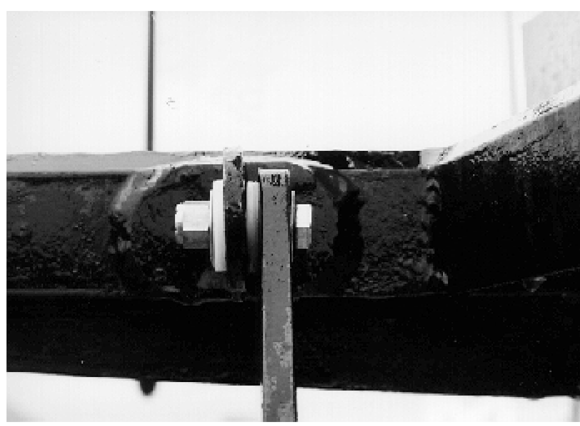
- Prohibit the infiltration of water into gaps between iron lantern frames and bronze window sub-frames, as well as other seams in iron or steel components.
- Maintain coatings and detailing that divert and shield water away from members that are prone to rust-jacking.
- When iron or steel components are repaired, be sure to coat any areas that have had their finish damaged with a corrosion prohibiting primer and top coat.
- Minimize condensation buildup in the lantern by providing adequate ventilation within the lantern at all times.

Ventilation

Nearly all, if not all, lanterns have a ventilation-ball-type vent and baffled secondary vents in various locations in the lantern and service room. These vents provided the fresh air for the illuminant and created a light draft that minimized condensation buildup inside the lantern. Air flow through the vents was also controlled by a variety of sliding registers and/or rotating dampers. To maintain an ambient humidity level in the lantern, the built-in ventilation system should be in working order, with all possible vents open to allow the maximum amount of air exchange to occur in the lantern. The exterior vent openings should be screened with brass or stainless steel screen to prevent bird and insect infiltration. Opening the lantern vents will aid in the overall ventilation of the lantern.

WPTC photo

Figure 24. The stainless steel through bolts used to join this bronze sash bar to the vertical lantern post is isolated from the bronze using a nylon washer as a barrier.



WPTC photo

Figure 25. This is a view of a typical dissimilar metal isolation solution; the steel ladder post (vertical member in the center of the image) is isolated from the aluminum lantern gallery deck with nylon washers. The bolt chosen for this application is made from Type 316 stainless steel.

Figure 26. Detail of handrail that is being deformed by rust-jacking.

Figure 27. This lantern vent opening has been covered with a fine stainless steel screen that prevents insect infiltration while maximizing air movement through the vent and into the lantern.

Lantern Glass

The lantern glass plays two important roles in the lantern system. First, the glass must be clean and clear to allow the greatest amount of light transmission. Second, the glass must be able to withstand high winds, driving rain, and airborne material (i.e., sand and other debris). It is absolutely essential that the glass meet these demands at all times. Proper installation care and replacement will ensure these demands are met.

Lantern Glass Installation

- Use only tempered or laminated glass for replacement of clear panels. Do not use acrylic or polycarbonate for replacement glass; these materials are easily scratched by airborne sand and will fog with time. The glass panes must be sized for code-required wind loads and code requirements for glazing next to or above walking surfaces. In most cases only laminated glass will be acceptable. (Lexan may be more suitable for replacement of colored panels in that they allow more light to pass through than colored glass.)
- When removing the astragals and clamps that retain the glass, take care not to damage the screws that hold the members in place. These screws are typically made of brass which is relatively soft.
- The most effective way to remove the glass is to cut any paint or sealant away from the glass with a sharp knife. Next, using handled suction cups designed for handling glass, carefully remove the glass from the frame.
- Before the new glass is installed, the channel in the frame must be completely clear of all old putty or sealant and corrosion. Any 'hard spot' left in the channel could cause a point stress on the glass, which in turn could cause the glass to crack or break.
- While the glass is out of the iron lantern frame, the iron should be inspected for corrosion. All corrosion that is present must be removed. Any bare iron surfaces should be painted with a corrosion-resistant coating system.
- When cutting glass to fit, it is imperative that the glass does not touch the frame in any location. This will prevent the glass from breaking when the lantern frame racks under windy conditions.
- The glass must rest on either soft wood (pine or cedar) spacers, commercially available Teflon gasket material (that is approximately 3/16 inch thick), or neoprene setting blocks. The rest of the glass should be bedded in pressure-sensitive neoprene or butyl-rubber-gasket material designed for architectural glass installation.
- Install the new glass using handled suction cups.
- Apply the neoprene or butyl-rubber gasket to the outside of the glass and install the astragals and clamps; only snug tighten the screws at first, then tighten again a few days later to allow the gasket to set.
- This system should prevent water from entering the window channel and in turn prevent future damage to the glass from rust-jacking. As an


WPTC photo

Figure 28.


WPTC photo

Figure 29.

SIDEBAR: Use of Lexan in Lantern Glass Replacement

In 1986 the wire-glass in the lantern of the Sombrero Key Lighthouse was replaced with Lexan (plastic) panels. A 1996 site visit found the Lexan panels hazed by sunlight and salt air exposure. This condition greatly reduces the transmission of light and therefore reduces the effective range of the aid to navigation. The inability of the Lexan panels to withstand the conditions of the marine environment gives the panels a short life expectancy when compared to glass. With these inherent limitations, Lexan or other plastic panels should only be used as a temporary repair and not be relied upon as a long-term lantern glass material.

Sombrero Key Lighthouse is located in open water in the Gulf of Mexico. In similar locations that experience hurricane force winds, laminated glass has proven successful for the lantern glass replacement. Laminated glass is made by sandwiching a piece of plastic film between two sheets of tempered glass. This technology produces a very durable panel with long lasting clarity that does not compromise the effectiveness of the aid to navigation or impact the historic character of the lighthouse.

Figure 28 (top left). Close-up view of severely hazed Lexan replacement panel. Note the limited visibility caused by only ten years of sunlight and salt air exposure.

Figure 29 (bottom left). Looking out through severely hazed Lexan panels, note the limited amount of light transmission; this greatly hinders the effectiveness of the aid to navigation. If the panels are not replaced, the degradation may continue and diminish the light transmission, ultimately rendering the aid to navigation ineffective.

WPTC photo

Figure 30. Close-up of a first-order lantern that retains its lantern glass; note the clarity.

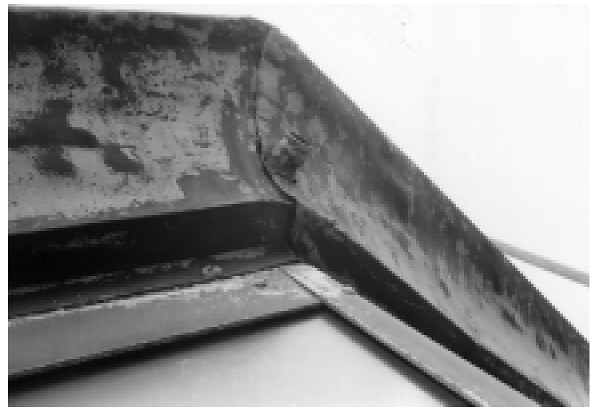
added measure, a bead of clear silicone caulk may be applied to the exterior side of the window/frame joint to shed water away from the joint.

- When curved glass is to replaced, professional assistance is recommended.

Lantern Roof

The lantern roof typically serves as the roof for the entire lighthouse; therefore it is essential that it and any guttering systems be weathertight. Traditionally, the lantern and lighthouse roof (as in the case of the caisson lighthouse) were either terne-coated metal or copper. The roofing was commonly laid in a standing-seam or flat-seam style. Any metal roofing patches should be made with like-kind materials soldered in place. If deterioration is excessive, a new roof which matches the original in material and configuration should be considered.

All rainwater guttering systems (lantern roofs or other tower roof forms) should be cleaned and checked for holes. All holes and non-functioning gutter system components should be repaired. Holes in sheet-metal built-in gutters must be repaired with a properly soldered repair to ensure the durability of the repair. Caulking should be considered only for temporary repairs until a proper soldered repair can be made. Guttering systems must discharge rainwater safely to parts of the site which are designed and maintained to receive concentrations of water flow.



WPTC photo

Figure 31. View of built-in gutter spout on a copper roof.

Gallery Decks

In most lighthouses gallery decks are cast-iron, sheet-metal-covered wood, stone, or concrete. These decks are generally laid directly on top of the wall structure and act literally as the roof for some portions of the lighthouse below. If the decking material is not weathertight, moisture can enter the interior of the lighthouse or lantern.

- When repairing gallery decking, use only like-kind materials.
- The decking should be sloped away from the lighthouse to shed the water away from the structure.
- Inspect all seams for water infiltration: in cast-iron decking there will be raised corrosion along the length of the seam; with flat-seam sheet metal there may be a leak present on the interior of the lighthouse; in stone decking there may be open gaps between the pointing and the stones.
- Flat-seam sheet-metal decking should be repaired with soldered patches or with selective removal and replacement with like-kind material; all new seams should be double locked and soldered.
- Cast-iron decking should first have all corrosion removed and the affected surfaces painted with

Figure 32. This sheet-copper-covered lantern gallery deck has been repaired several times by soldering sheet copper patches over the holes. This method of repair, if performed properly, greatly increases the life span of the roof covering.

a corrosion-inhibiting coating. The seams should then be caulked with either butyl-rubber or polysulfide caulking.

- Some coating systems are very slick when cured; therefore it is essential that non-skid materials are used on gallery decks that do not already have a non-skid surface texture.
- Deteriorated portions of iron or steel can be repaired using metal polymers that can be molded and shaped to match existing textures and contours.
- Gaps in the joints between stone decking should be raked out and repointed with a mortar that matches the original in color and strength. Damaged stones should be carefully removed and replaced with like-kind stones.

Removal and Application of Protective Coatings

WARNING: When performing any of the following treatments it is essential that the classical lens and clockworks (if extant) be protected.

As a protective measure and for daymark purposes, lanterns were historically painted. As part of a repair treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color. Ultimately, as part of any preservation treatment, the entire lantern should have all loose and flaking paint removed and a new coating applied according to the manufacturer's specifications.

Several factors should be considered when removing paint from lantern components. The combination of ferrous (iron and steel) and nonferrous (bronze, brass, copper) metals present different challenges when performing paint removal. As mentioned in the **Iron** section, paint can be removed from iron using low-pressure-aggregate blast methods and chemical strippers. These methods can be used on bronze and brass as well; however the choice of blast media and chemicals is different.

Because of the relative softness of bronze, brass, and copper when compared to iron, a less aggressive blast media is desirable. Walnut shells and bicarbonate of soda are acceptable blast media for bronze, brass, and copper. Before use, the media should be tested in an inconspicuous location at various pressures to determine if the treatment will damage the substrate.

Chemical strippers used on bronze, brass, or copper should be designed for use on these metals. Tests should be performed with the chemical stripper before use on the entire lantern. The stripper used should not cause etching or corrosion of the bronze or brass substrate.

Bronze, brass, and copper lantern components historically may or may not have been painted. These metals will form a protective oxidized surface coating or *patina* if not painted. This is the greenish brown tint that is commonly seen on outdoor bronze sculpture. Brass typically found on the interior of the lantern, however, is traditionally kept bright and shined through regular cleaning and buffing by the lighthouse keeper. To maintain a bright shiny finish, the brass may be coated with a finish such as clear lacquer that can be applied to maintain this bright appearance (see following sidebar on maintenance of classical lenses). When painting bronze or brass components on the exterior of the lantern, all surfaces should be wiped clean with a metal preparation solvent to remove any chloride residue or other contaminants. If chemical strippers were used, any remaining stripper residue must be neutralized prior to painting.

For more information on paint application methods refer to the discussion on paint and coating systems in the **Iron** section.

Limited Replacement In Kind

When replacing all extensively missing or deteriorating lantern components, such as a ventilation ball or decorative gutter spout, the replacement materials need to match the old materials both physically and visually, i.e., the metals should not have a galvanic response.

When replacing deteriorated bolts or other hardware, use matching materials of the highest quality and resistance to the marine environment. When replacing bronze bolts or other elements use Silicon Bronze alloy 655 or Naval Bronze; both alloys have a high corrosion resistance and can be left unpainted to naturally oxidize or *patina*. When iron or steel components are to be replaced because of severe deterioration, stainless steel should be considered as a substitute. Given the complexity of the issues and the potential application, however, the selection of the proper grade for use in a marine environment requires careful evaluation by an engineer.

Installation of Modern Utilities and Equipment

Many historic lighthouses have been upgraded to either alternating current (AC) or solar power during the conversion to automatic operation. During this conversion various pieces of equipment

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Figure 33. To minimize damage to historic wood beadboard panelling, these new panels should have been installed on a sheet of plywood attached to the historic wood beadboard panelling in four locations. These batteries stored on the floor should be in containment boxes in case the batteries leak.

such as electrical panel boxes, conduit, battery racks, and batteries have been installed. As this equipment ages or becomes obsolete, new fixtures may need to be installed. When installing new utilities and equipment the following factors should be considered:

- Use existing openings to run conduit through. Avoid boring or cutting holes in interior floors and exterior gallery decks and walls.
- Install electrical panel boxes on plywood panels that are mounted to the historic walls. This will minimize the impact on interior masonry, iron, or wood walls. Do not mount panels on built-in cabinets.
- Attach conduit with clamp or strap-type fasteners that do not impact the historic fabric by use of screws or nails.
- Store batteries in spill-proof boxes that will contain the liquid battery contents in case of an accident.
- Avoid mounting heavy solar panels and auxiliary lights on the outside of historic gallery deck rails; this will create eccentric loading that will ultimately damage the railing.
- When a classical lens has been converted to AC or solar power, retain the extant accessories such as lens jacks, clockwork cranks, wrenches designed for use with the lens, etc., that were used for the care and maintenance of the lens.


WPTC photo

Figure 34. When this first-order classical lens was converted to AC power, the original drive gear (pictured here) was the crank used to wind the clockworks.

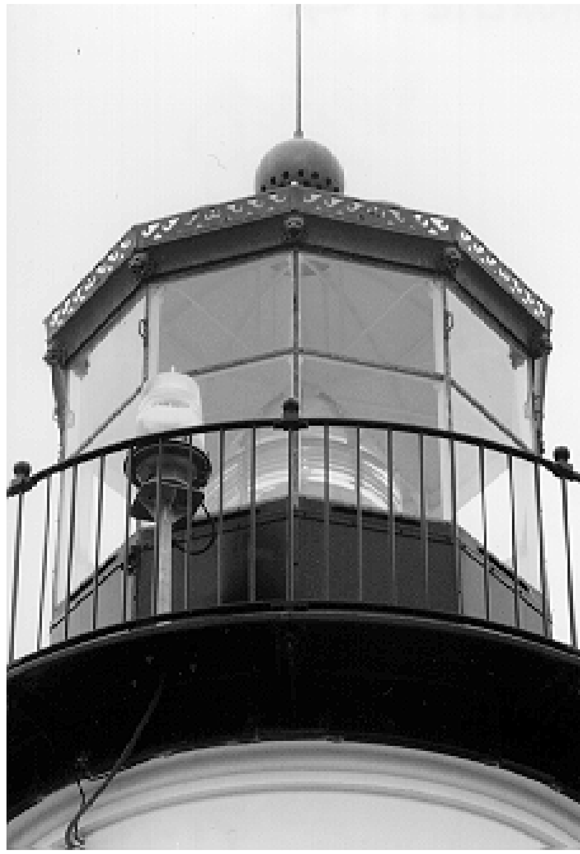

WPTC photo

Figure 35. This is an acceptable auxiliary light installation. The light is mounted on an aluminum pedestal that has been bolted to the replacement aluminum deck.


WPTC photo

Figure 36. This c. 1926 lens was designed to be AC powered; the original lens jacks are still in place. The three jacks (the third is obscured by the brass bearing cover) were used to lift the lens assembly so that bearings could be serviced.

SIDEBAR: Maintenance of Classical Lenses

As noted in Part III., historic lighthouse lenses are considered character-defining features of a lighthouse. Briefly, a classical Fresnel lens (also called the beacon or optic) is a large composite illumination device which can include hundreds of separate pieces of glass all organized to capture radiant light and create a directed beam. Glass segments are either secured to each other or to the brass superstructure. Segments are secured to each other by means of a beveled cut (along the edge) of a prism and a little litharge (white lead) glazing putty to hold them in place. Prisms are also secured directly into the brass framework with glazing putty and wood shims placed in between the glass and brass to position the prism. In addition, some lenses also have a series of brass or bronze retaining bars to help secure the sections.

The glass used in Fresnel lenses was manufactured in France and is quite hard and scratch resistant. It is also quite brittle, which lends itself to chipping and fracture. By comparison, more modern flint (which contains lead) glass is softer, quite clear, and comparatively easy to scratch. Litharge glazing putty was the standard glazing material of its time. It is composed of linseed oil, whiting (calcium carbonate), and either a lead oxide (yellow to reddish) or a lead carbonate (white) filler and dryer. The use of litharge is the source of many of our current preservation problems.

During the historic period of operation, maintenance practices were prevention oriented. Every effort was made to prevent inadvertent damage or scratches to the glass, corrosion of the brass, or loss of a prism through disintegration of the glazing putty. In addition, the turning mechanism, clockwork, and lantern room were kept meticulously clean. Condition assessments of numerous classical lenses reveal that most damage and deterioration encountered today occurred recently.

Recommendations for Maintenance

Historically Fresnel lenses were 1) dusted daily, 2) cleaned with “spirits of wine” or vinegar, and 3) polished with rouge once a year.

The goal of preventive care is to substantially reduce loss of original historic material to deterioration and inappropriate maintenance procedures. Preventive care aptly describes those activities which minimally trained personnel can utilize to keep a lens in a stable state. The introduction of new materials, preservatives, and/or coatings, as well as the removal of established corrosion layers, all constitute a degree of intervention which, in the absence of appropriate training and experience, are beyond the scope of preventive care.

Inspection

- Examine and document the condition of the classical lens before preventive care procedures are carried out. (If deteriorated glazing has resulted in prisms not being firmly seated, then the optic cannot be safely cleaned.)

Handling

- Pad the work area with sheets of expanded polyethylene foam.
- Remove jewelry such as rings, bracelets, and long necklaces, and belts that might scratch or chip the objects. Preferably, wear an apron to ensure the prisms will not be scratched.

- Moisture, oils, and acids left from fingerprints will disrupt and eventually etch these delicate surfaces. Use snug fitting latex gloves when handling these objects. (Handle classical lenses as little as possible.)
- Do not apply pressure to annular rings which are not supported in the brass, or bronze superstructure. Be especially careful not to apply pressure from the interior of the lens. This is a major cause of damage because unsupported annular rings and bullseye lenses can easily fall out.

Cleaning the brass

Historically, a form of calcium carbonate called whiting was used as a mild cleaning agent on the brass, and jeweller's rouge was used as a polishing compound. These materials maintained a clean and polished appearance on the copper; however, the practice needed to be repeated regularly to keep corrosion in check. Preventive care should shy away from a regime of repolishing because the brass is continually being sacrificed and lost to achieve a shiny appearance. If a polished appearance is desired, a more conservative approach would have the polished lens coated to isolate the copper alloy from the environmental agents which cause corrosion. Clear coatings are often used today, but their use can bring about a new set of associated problems. Their success is dependent upon surface preparation, the means of application, and the degree of exposure to ultraviolet light. A poorly applied protective coating may cause differential corrosion, and a mottled appearance will develop. If surface preparation has not been adequate, the coating is likely to peel, and the useful lifetime of clear coatings exposed to elevated levels of ultraviolet (especially when within a tower) is controversial. These problems are difficult to deal with because they require the complete removal of the coating in order to effect a remedy. What emerges here is the realization that although all classical lenses were historically treated in about the same way, today's decision to polish brass should be based on what technical expertise is available and at least some consideration of the following factors: 1) What kind and how much corrosion is present upon the brass? 2) Will the lens be in an urban environment? 3) Will the lens remain in the tower, or has it been relocated? 4) Is staffing sufficient to carry out scheduled maintenance?

Brass which has a well-established reddish brown cuprite corrosion layer is not considered to be actively corroding. The decision to polish brass in this condition is an aesthetic one. Once polished, the metal then needs to either be repolished periodically or it needs to be coated to preserve a polished appearance.

Cleaning the glass

The historic record indicates that the prisms were routinely washed with mild soap or "spirits of wine." Periodically, the prisms were also rubbed down with whiting, or a combination of whiting followed by rouge to polish the glass. Keepers were instructed to first brush the glass with a feather brush to remove surface dust. Before removing airborne particulates which have settled in, try to determine if in fact the deposit contains abrasive particulate. If the 'dust' is particularly abrasive, or if a large quantity of deposits is to be removed, then a vacuum aided by a soft mop-type artist's brush will be effective. Be sure that sufficient hose is available to avoid the vacuum endangering the lens, and that the hose attachments are nonmetallic to avoid scratching. If the deposits are light and nonabrasive, then it is suggested that the glass be wiped down with lint free cotton toweling moistened with distilled water. Small amounts of denatured alcohol can safely be added to form an alcohol and water solution, especially if the deposits are a combination of dust and oils. It is usually recommended that alcohol be added until the solution is an effective cleaning solution. The exact proportions will vary for each site because of such environmental factors as proximity to industrial sites, freeways, or visitor contact. Be alert to the presence of a clouded glass surface. If noted, a conservator should be contacted. A clouded surface indicates that the glass is deteriorating.

Care for deteriorated putty

If human error in cleaning, handling, and/or moving is overall the most serious threat to classical lenses, then deteriorated glazing putty is the second most serious threat. The consolidation of

Figures 37 and 38. Joe Cocking (above) and Nick Johnston (below) restore a classical lens at the U.S. Coast Guard Exhibit Center.

porous putty conforms to *The Secretary of Interior's Standards for Rehabilitation* by preserving as much original historic material as possible; the National Park Service, Division of Conservation, is currently evaluating a variety of synthetic resins to establish which is best suited as a consolidant for the preservation of historic glazing putty. Our approach had been to try and reconstitute the original putty. In addition, substantial cost savings are realized by consolidating the original putty both because it is a less expensive treatment option than reglazing, and because replacing a hazardous material requires proper abatement, control, and disposal procedures. Unfortunately, consolidation is only feasible if the original putty is porous and adsorbent enough to accept the introduction of a solvented resin. Preventive care as it applies to litharge glazing putty begins with establishing a monitoring program to determine if the putty has deteriorated. This is accomplished by the use of lead indicator test patches or strips. Indicators do not establish levels of lead containing compounds, only their presence. The relative rate of deterioration is established by a combination of condition assessment and monitoring. To monitor, wet clean the area and monitor periodically for additional lead particulate deposition. Working in the presence of lead oxide or lead carbonate particles requires that the worker wear appropriate protective clothing and a respirator rated for the removal of lead bearing particulate. Additional state or local regulations may also apply. If a lens is in your custodial care by means of a loan agreement, then only the owner is authorized to make decisions about the care and treatment of a lens. Because of the inherent health hazards, it is strongly advised here that only trained personnel attempt to address litharge glazing putty preservation issues. At present, and until a more satisfactory solution is found, both the National Park Service and the U.S. Coast Guard often stabilize loose lenses or prisms by the localized addition of a vinyl glazing compound.

A classical Fresnel lens with significant deterioration requires stabilization and perhaps restorative treatment and may require a professional conservator.

For more information on the maintenance of classical lenses, refer to the forthcoming NPS *TECH NOTE: Preventive Care for Classical Lighthouse Lenses.*

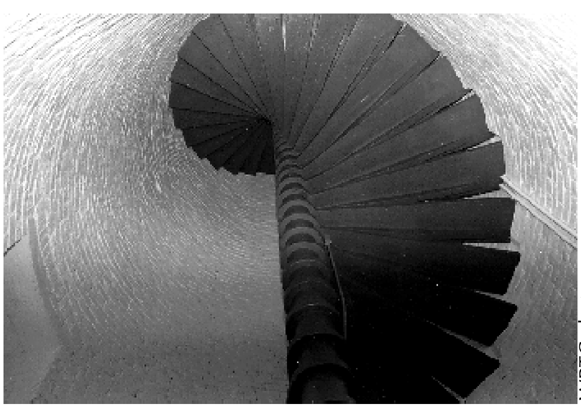
NMI photo

Historic Lighthouse Preservation:

INTERIORS

Figure 1. Cape Henry Lighthouse interior at Fort Story, Virginia.

Historic lighthouse tower interiors are typically simple and utilitarian. Unless used as a residence, most lighthouse towers had little more than a wood, iron, or masonry stairway leading to the lantern and compartments on the ground level for the bulk storage of oil for the light. In lighthouse towers that also served as the keeper's residence, the interiors were typically finished with beadboard paneling or plaster, and trim features were typically those that were popular at the time of lighthouse's construction. In more prominent locations, interior finish detailing may be a little more grandiose, reflecting the skills of the craftsmen who constructed lighthouses. Because they are unique, these interior characteristics are considered character-defining and should be preserved. Regardless of the level of detailing and ornament found in a lighthouse, the building techniques employed were typically unique to lighthouse construction.



WPTC photo

Figure 2. Utilitarian light tower interior at Cove Point Light Station, Maryland.

WPTC photo

Figure 3. Highly decorated interior of the Cape Henry Light Station (second tower), Fort Story Virginia

Deterioration of Historic Lighthouse Interiors during the Mothballing Period

Damage caused by the ever-present harsh marine environment is readily apparent when discussing the deterioration of exterior lighthouse features. The forces that act on the exterior of the lighthouse may also have a detrimental effect on interior lighthouse features as well. Many factors contribute to this deterioration. During the time a lighthouse is mothballed, the likelihood of such deterioration is increased. If these damaging conditions are not addressed, the lighthouse may deteriorate from the inside out.

Why do historic lighthouse interiors deteriorate?

- **Moisture infiltration:** water entering the lighthouse through holes in the roof, gallery deck(s), lantern glass, exterior sheathing, and gaps around doors or windows.
- **Condensation buildup:** condensation forming within the tower caused by exterior temperatures and ambient humidity. Masonry lighthouses are especially susceptible to this condition.
- **Neglect:** lack of maintenance, i.e., cleaning, painting, or repair of interior features before or during the mothballing period.
- **Inappropriate treatments:** removal of original fabric or the obscuring of historically significant interior elements.

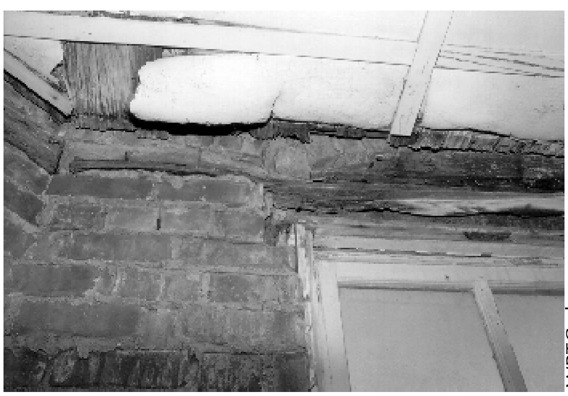


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Figure 4 (left). Extensive interior finish deterioration in a lighthouse that had holes in the roof which were not repaired.

Figure 5 (above). Excessive condensation buildup in this lighthouse caused the interior plaster finish and some mortar joints to fail.

PRESERVATION TREATMENTS: Minimizing Condensation Buildup

The preservation of historic lighthouse interiors is a multistep process. The first step in any lighthouse preservation project is to weatherize the exterior. This step will eliminate the threat of damaging moisture infiltration. The second step is to mitigate any condensation that may build up in the interior of the lighthouse. The third step is to monitor the interior environmental conditions to identify any problems that may arise before they cause more damage. The fourth step is to do no further damage to the interior during equipment installation or removal or during any rehabilitation efforts. This section will focus on minimizing condensation buildup in lighthouse interiors during the mothballing period. (Repair and mothballing treatments to **Masonry**, **Iron**, and **Wood** components can be found in their respective sections elsewhere in this handbook.)

As humidity levels increase in a lighthouse, the plaster, wood, iron components, and masonry are affected. Increased moisture content in the porous materials—wood, plaster, and mortar joints—causes significant damage. Increased moisture level in the wood makes way for the growth of fungi and attracts wood-eating insects such as termites. Increased moisture levels in plaster will cause mildew which holds more moisture in the plaster and in time will cause the plaster to delaminate and break away from the lath substrate. Increased moisture content in the mortar joints will cause the leaching of the lime from the mortar, which results in the failure of the joint. Increased moisture will cause any exposed iron to corrode or rust. These conditions are easily avoided if the lighthouse is adequately ventilated.

Once the exterior has been made weathertight, adequate air exchange is essential throughout the lighthouse. The needs of each historic lighthouse must be individually evaluated because there are so many variables that affect the performance of each interior space once the lighthouse has been made weathertight. A mechanical engineer or a specialist in interior climates should be consulted, particularly for lighthouses with significant interiors.

When looking at the type and amount of interior ventilation needed for a closed-up lighthouse, there are four critical climate zones: cold and damp (Pacific northwest and northeastern states); temperate and humid (mid-Atlantic states, coastal areas); hot and humid (southern states), and the extremely cold (freezing) and seasonably damp (Great Lakes). Each climate zone has special ventilation considerations.

The absolute minimum air exchange for most mothballed lighthouses consists of one to four air exchanges every hour; one or two air exchanges per hour in winter and often twice that amount in summer. Even this minimal exchange may permit mold and mildew in damp climates. Monitoring the lighthouse for approximately six months during the initial ventilation period will provide useful information on the effectiveness of the ventilation solution.

There is no exact science for how much ventilation should be provided for each lighthouse. There are, however, some general rules of thumb:

- During months of high humidity, it is important to keep the air within the tower moving at all times.
- The most difficult lighthouses to adequately ventilate without resorting to extensive

louvering and/or mechanical exhaust fan systems are masonry lighthouses in humid climates. For this lighthouse type nearly every window will need to be fitted with a louver that occupies at least 50 percent of the window opening.

- Take advantage of prevailing winds during the installation of louvers. This will provide the maximum amount of natural passive (non-mechanical) ventilation.
- The natural chimney effect in most lighthouses is best utilized by installation of vents at the top and bottom of the lighthouse only. Consider vandalism when locating the lower vent.
- Be sure the built-in lantern vents are open and screened. This will also capitalize on the chimney effect that will naturally draw the air up and out of the lighthouse as the hot air in the tower rises.
- In lighthouses with AC power, fans controlled by thermostats and timers provide effective ventilation that can be tuned to operate in reaction to day-to-day climatic change. One fan in a small- to medium-sized lighthouse can reduce the amount of louvering substantially.
- If electric fans are used, study the environmental conditions of the lighthouse to determine whether the fans should be controlled by thermostats or automatic timers. Humidistats, designed for enclosed climate-control systems, generally are difficult to adapt for open mothballing conditions. How the system will draw in or exhaust air is also important. It may be best to bring dry air in from the lantern or upper levels and force it out through lower tower windows. Additionally, less humid dry air is preferred to damper night air; this can be controlled with a timer switch mounted to the fan.
- Small preformed louvers set into a plywood, polycarbonate, or lexan panel generally cannot provide enough ventilation in most moist climates to offset condensation, but this approach is certainly better than no louvers at all. Louvers should be located to give cross ventilation; interior doors should be fixed ajar at least 4 inches (10 cm) to allow air to circulate; and hatches between floors should be left open.
- The type of ventilation should not undermine the security of the lighthouse. The most secure installations use custom-made vents and heavy millwork louvers set into existing window openings. This louver type is also effective in preventing rain from being blown into the lighthouse during storm conditions.

  In some extreme circumstances, heat will be needed during the winter, even at a minimal 45° Fahrenheit (7° Celsius), and using forced-fan ventilation in summer and will require retaining electrical service. For masonry lighthouses the interior temperature should be kept above the spring dew point to avoid damaging condensation. In most lighthouses the need for summer ventilation outweighs the winter requirements.
- Lighthouses using prime power (fuel-powered generator) with hot-air exhaust (not combustion emissions) into the lighthouse interior may not require a vent near the base. The rising heat will cause a natural upward draft to occur. To take advantage of this natural draft, vents should be located near the top and bottom of the tower. The vents near the bottom will allow fresh ambient temperature air into the tower. Vents located near the top of the tower will allow the hot air to escape. This configuration will help keep the interior of the tower dry and minimize the heat buildup that could damage interior finishes.

(For more information on window louver types and installation techniques refer to the **Windows** section.)

Use the gentlest means possible; all treatments should be reversible. Preserving the lighthouse interiors during the mothballing period will minimized the cost of repairs over the life of the lighthouse.

Historic Lighthouse Preservation: GROUNDS

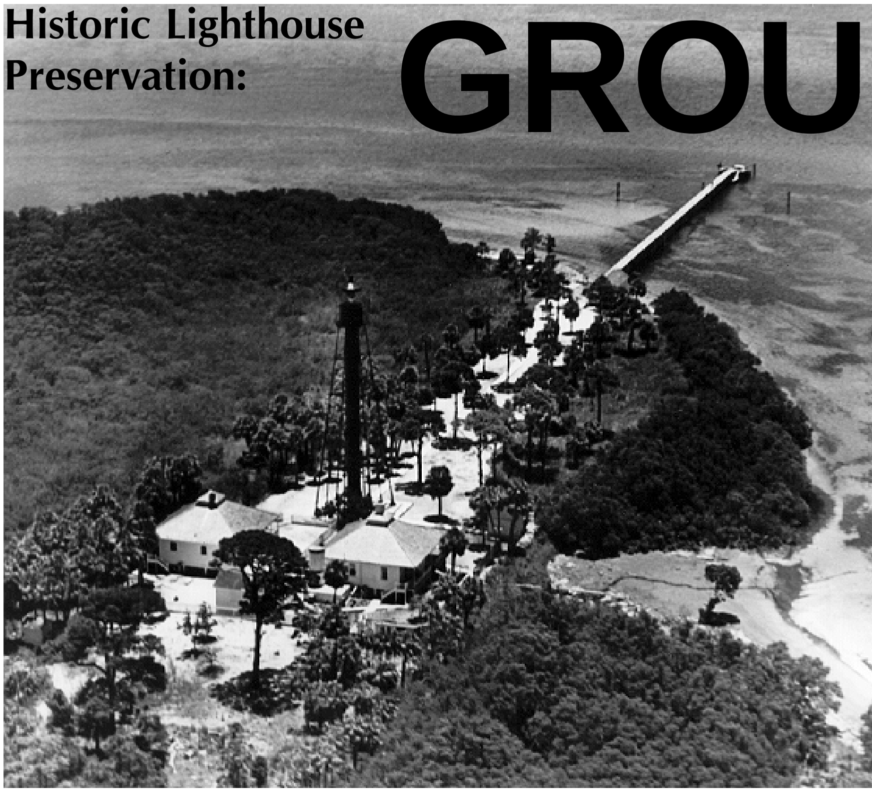

Figure 1. Historic aerial view of Anclote Key Light Station, Florida.

The landscape and ancillary buildings immediately surrounding a lighthouse are as important to defining the overall character of the light station as the lighthouse itself. The ancillary structures that comprise a light station—keepers' quarters, fog signal building, oil house, cisterns, privy, storage buildings, barn, boat sheds, etc., and the manipulated landscape—berms, sidewalks and pathways, and plantings, compromise the cultural landscape of the light station. Archeological sites in the vicinity of previously existing buildings or possible prehistoric sites also contribute to the cultural landscape. These features and their relationship to one another are character-defining and therefore should be preserved. The following are general guidelines for historic light station site preservation based on the *Secretary of the Interior's Standards for the Treatment of Historic Properties*

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Figure 2. View of the two light towers at Cape Henry, Virginia. The relationship of the two generations of lighthouses is part of the cultural landscape at the Cape Henry Light Station.

WPTC photo

Figure 3. Outbuildings, fences, and walkways are all part of the cultural landscape of a historic light station.

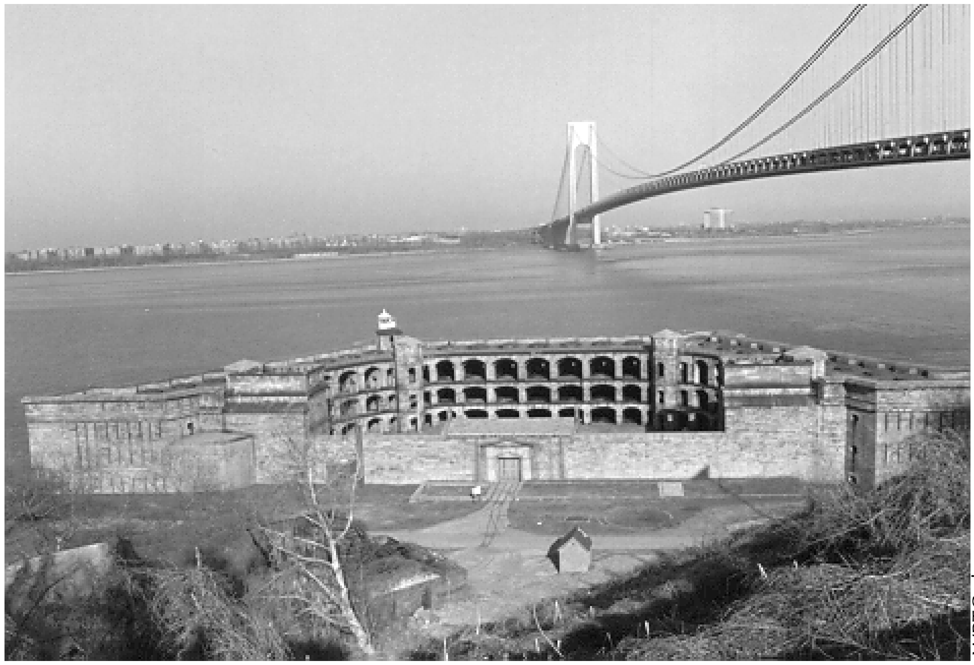

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Figure 4. Some light station sites are part of a larger cultural landscape such as this early 20th-century lighthouse on a salient of Fort Wadsworth, a Civil-War-era stone fort in New York Harbor.

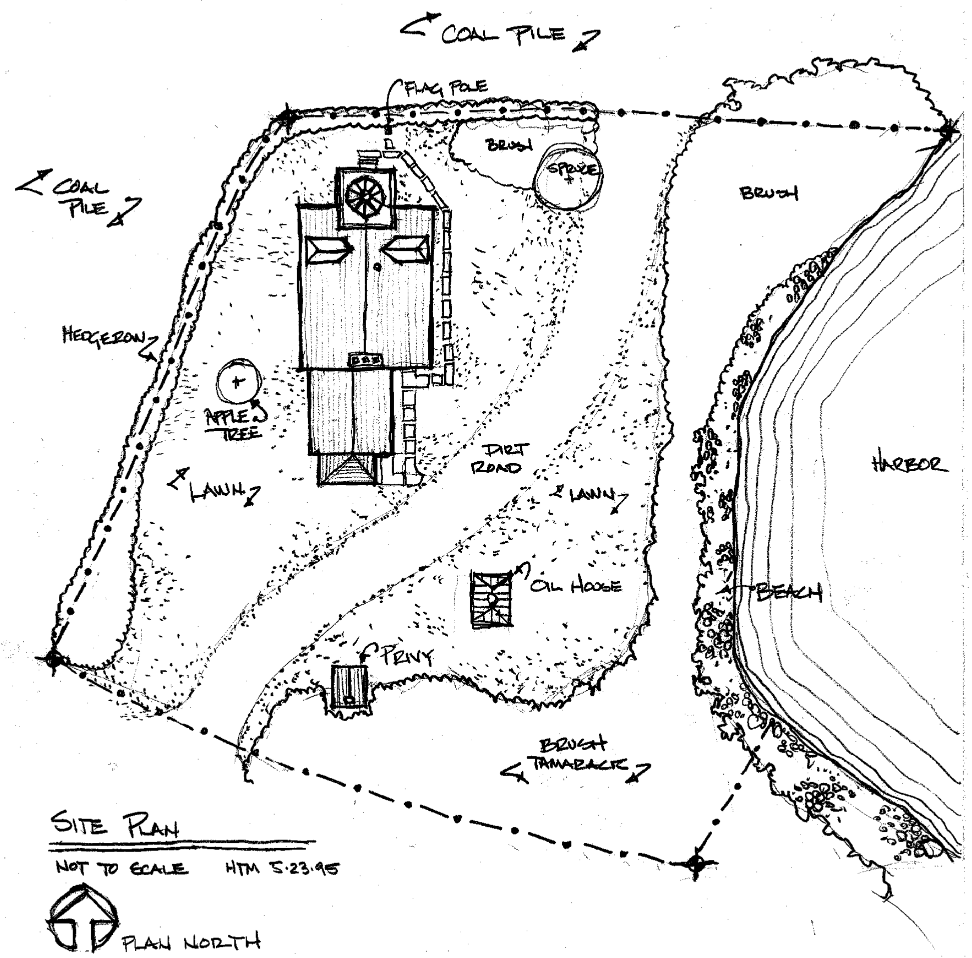


Figure 5. A simple sketch site plan records the relationship of a light station's buildings and features. This type of recordation should be dated and filed with the lighthouse maintenance records. (WPTC drawing by H. Thomas McGrath)

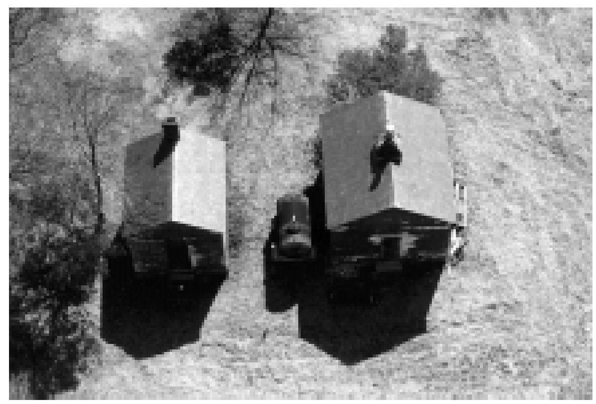
with Guidelines for the Treatment of Cultural Landscapes (1996).

General Site Recommendations

- Identify all character-defining features of the light station's site, including all associated ancillary structures; manipulated landscape for the purpose of facilitating the operation of the light station; and any plantings such as fruit trees, shade trees, gardens, and archeological sites. If potential archeological sites are not readily identifiable, contact a professional archeological firm to perform an archeological site survey. Once all features are identified, they should be documented photographically and located on a site plan that is kept with the light station maintenance file.
- Evaluate the existing condition of materials and features to determine whether more than protection and maintenance are required, that is, if repairs to light station building and site features will be necessary.
- Provide continued protection of historic light station building materials and plant features through appropriate cleaning, rust removal, limited paint removal, reapplication of protective coating systems, and pruning and vegetation management.
- Repair features of the buildings and site by reinforcing historic materials using recognized preservation methods. The new work should be unobtrusively dated to guide future research and treatment.
- Do not remove historic materials that could be repaired, use improper repair techniques, or fail to document new work.
- When performing any work on the lighthouse or site, retain the historic relationship between historic buildings and the landscape.
- When necessary, stabilize deteriorated or damaged historic site features as a preliminary measure before undertaking appropriate preservation work.
- To avoid diminishing the station's character, do not alter site features which are important in defining the overall historic character of the property.
- Do not remove or relocate historic light station buildings or landscape features, thus destroying the historic relationship between the lighthouse, the buildings, and the landscape.

WPTC photo

Figure 6. The relationship of the keeper's quarters to its support buildings, in this case a privy and a storage building, are essential to understanding how the light keeper lived and worked.



WPTC photo

Figure 7. The relationship of this oil house (right) and generator building (left) show the variety of structures associated with a manned light station.

WPTC photo

Figure 8. These circa WWII observation towers are part of the evolution of the light station site.

Figure 9. View of a highly intact historic light station in California. All principal structures that made up the light station are intact including the large concrete rain water catchment (in the foreground) and the below-grade wood cisterns (just the lids are visible in the center of the photo) used to store the rainwater to produce steam for the fog signal. The preservation of a site at this level of integrity is essential to understanding the relationship of the light station buildings and their contribution to the station's overall operation.

WPTC photo

Archeological Recommendations

- Minimize disturbance of terrain around buildings or elsewhere on the site, thus reducing the possibility of destroying or damaging important landscape features or archeological resources.
- Survey and document areas where the terrain will be altered to determine the potential impact to important landscape features or archeological resources.
- Protect important archeological resources by preserving them in place.
- When preservation in place is not feasible, plan and carry out any necessary investigations using professional archeologists and modern archeological methods.
- Do not introduce heavy machinery into areas where it may disturb or damage important archeological resources.

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Figures 10 (left) and 11 (above). Views of potential archeological sites.

- Do not permit unqualified personnel to perform data recovery on archeological resources. This will prevent the loss of important archeological material through improper methodology. (See "Archeological Documentation" under Part VI., **Resources** for additional information.)
- Do not leave known archeological material unprotected so that it is damaged during preservation work.

Landscape Features

- Preserve important landscape features; this includes ongoing maintenance of historic plant material.
- Protect and maintain the light station buildings and sites by providing proper drainage to assure that water does not erode foundation walls, drain toward the buildings, or damage or erode the landscape.
- Do not introduce heavy machinery into areas where it may disturb or damage important landscape features.
- Do not allow important landscape features to be lost or damaged through lack of maintenance.
- Do not advertise location of archeological sites, unless protection mechanisms are in place.

Security

- Protect light station buildings, landscape features, and archeological sites against arson and vandalism before preservation work begins, i.e., erect protective fencing and install alarm systems that are keyed into local protection agencies. If possible, contact the local community to see if the light station site can become part of a police patrol or neighborhood watch program.

Limited Replacement In Kind

- Replace in kind extensively deteriorated or missing parts of the light station buildings or site where there are surviving prototypes such as partial building remains, part of a fence, portions of a walkway, or parts of other site features. New work should match the old in materials, design, color, and texture, and be unobtrusively dated to guide future research and treatment.
- Do not replace an entire feature of the building or site when limited replacement of deteriorated and missing parts is appropriate.
- Do not use replacement material that does not match the building site feature, or fail to properly document the new work.

WPTC photo

Figure 12. Historic plantings, such as this ice plant (the ground cover at the bottom of the image) planted as a fire break around the light station structures, are part of the light station's cultural landscape and should be preserved.

USCG photo

Beyond Basic Preservation: REHABILITATION

Figure 1. Rehabilitation of Anacapa Island Lighthouse.

Rehabilitation is defined as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.

Rehabilitation as a Treatment: When repair and replacement of deteriorated features are necessary; when alterations or additions to the property are planned for a new or continued use; and when its depiction at a particular period of time is not appropriate, *rehabilitation* may be considered as a treatment. Before undertaking work, a documentation plan for *rehabilitation* should be developed.

Standards for Rehabilitation

- Use the property as it was used historically or find a new use that requires minimal change to distinctive features.
- Preserve the historic character and character-defining features (continuum of property's history).
- Do not make changes that falsify the historical development.
- Repair deteriorated features. Replace a severely deteriorated feature with a matching feature (substitute materials may be used).
- New additions and alterations should not destroy historic materials or character. New work should be differentiated from the old, yet compatible with it.

This is a summary of the central ideals of the *rehabilitation* treatment standards excerpted from the *CRM* article, "Historic Preservation Treatment: Toward a Common Language" by Kay Weeks (Vol 19, No. 1, 1996, pp. 32-33).

CASE STUDY: Design for Missing Historic Windows

by Michael Seibert, WPTC

A variety of factors should be considered when designing new windows for a historic lighthouse where no original windows remain. New windows should be designed or constructed only if the original historic windows are completely missing. The new window design should be a restoration based on historical, pictorial, and physical documentation, or a new design that is compatible with the historic character of the lighthouse. If adequate documentation exists, windows that were blocked in or boarded up after the historic period should be restored.

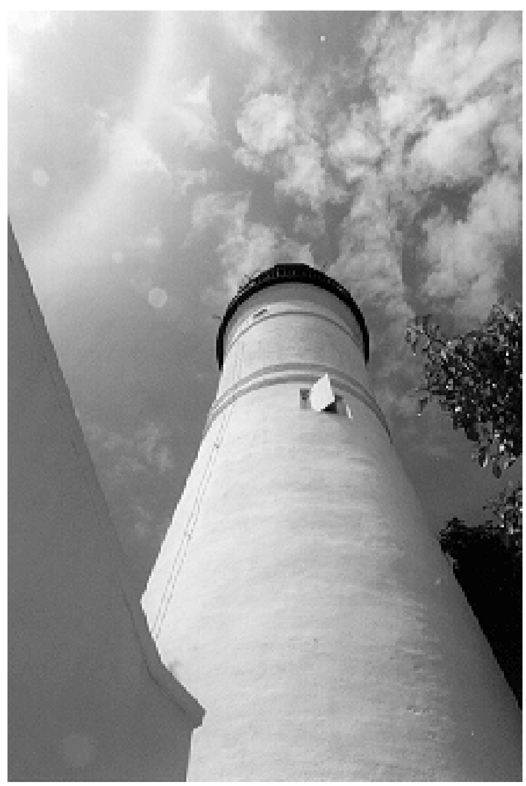
When developing a new design, there are many resources available to guide the design of missing features. Archival sources include historic lighthouse plans and photos. These are primary sources for historically accurate information. If these resources are unavailable, there may be clues on the existing window frames, such as hinge and lock mortises in casement type windows or remnants of parting beads or stops that would indicate sash thickness or size of double-hung windows. When designing a new window, avoid creating a false historical appearance based on insufficient historical, pictorial, and physical documentation.

When replicating missing historic lighthouse windows, it is essential to accurately reproduce the following character-defining elements of a window:

- Type of window: double hung, casement, or fixed sash
- Size and number of lights or panes of glass

WPTC photo

Figure 2.



WPTC photo

Figure 3.

• Muntin (the vertical and horizontal members that divide the panes of glass) profile and size

• Size and shape of the sill, head, and jambs

Figures 2 through 5 illustrate successful replacement window designs. These solutions can be easily adapted to most historic lighthouse window designs. During the rehabilitation of the lighthouse shown in Figures 2 and 3, the metal multiple-light windows were reproduced based on the remnants of the original windows and on historic lighthouse construction documents from a lighthouse built in the same region during the same time period. During the restoration of the window opening, the granite window frame was also replicated from remnants found in another window opening. Even the tooling pattern on the stone surface was reproduced. A single-leaf, vertical-plank shutter can be seen on the lighthouse in Figure 3. This detail was also based on existing evidence. Not only is this detail historically accurate, but it has protected the lighthouse during hurricane-force winds.

The wooden, double-hung, six-over-six window were reproduced from historic photographs. Subtle details such as molding profiles and hardware that could not be determined from historic photographs were based on lighthouses constructed by the same builder during the same time period. Figure 4 shows a close-up of the exterior side of the window; note the simple detailing and lack of profiled trim. These characteristics are typical of lighthouses constructed before the Civil War. Figure 5 shows the lighthouse after the installation of the replacement windows.

WPTC photo

Figure 4.

WPTC photo

Figure 5.

CASE STUDY: Design for Missing Historic Doors

by Michael Seibert, WPTC

When designing new doors for a historic lighthouse where the original door is missing, a variety of factors should be considered. A new door should be designed or constructed only if the original historic door is completely missing. The new-door restoration should be based on historical, pictorial, and physical documentation, or be a new design that is compatible with the historic character of the lighthouse.

When developing a new design, there are many resources available to guide the design of missing features. Archival sources include historic lighthouse plans and archival photos. These are primary sources for historically accurate information. If these resources are unavailable, there may be clues on the existing door frame such as hinge-and-lock mortises that indicate the direction of door swing and hardware sizes and locations. When designing a new door, avoid creating a false historical appearance because the replacement door is based on insufficient historical, pictorial, and physical documentation.

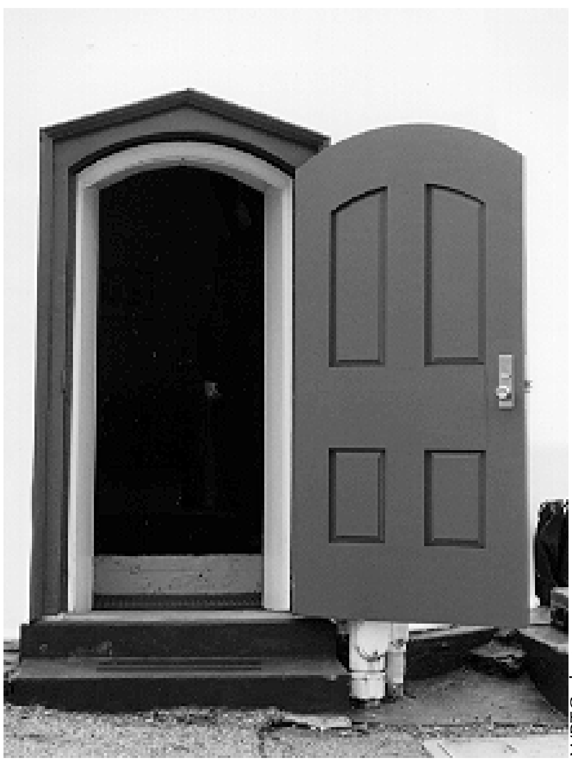


Figure 6.

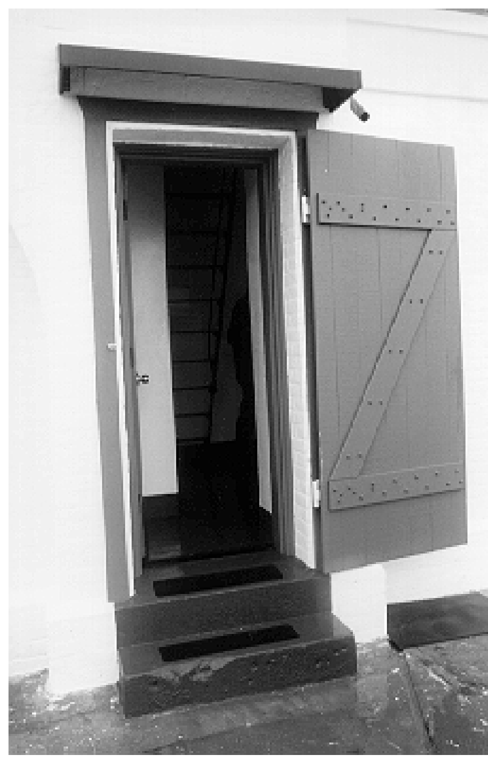


Figure 7.

Figures 6 through 9 are examples of successful replacement door designs. The solutions displayed here can be easily adapted to most historic lighthouse door designs. The wood replacement door design in Figure 6 was based on wood-frame and panel-construction-style doors commonly used when this lighthouse was constructed in 1928. The only difference made to the c. 1928 design was the upgrade of the hardware to stainless steel components. This door design was based on information from historic photographs from the U.S. Coast Guard archives and evidence found during the rehabilitation of the lighthouse. Historic photographs showed a vertical plank door on the exterior.

***Vertical wood plank door*:** The design for the door in Figure 7 was based on the information in the historic photographs. The materials used during the construction of this door were chosen for their durability. The wood chosen was fir, which was primed before assembly to ensure all surfaces would be coated to deter rot caused by damp wood. The planks were joined to the 'z' batten with stainless steel screws to decrease maintenance and eliminate the possibility of rusting fasteners. The hinges are salvaged bronze strap hinges that will also require minimal maintenance. The copper hood or awning above the door is another traditional protective measure for historic lighthouse doors.

***Wood frame and panel door*:** Partial remains of a wood frame and raised panel was found inside the structure during rehabilitation. This evidence was used in conjunction with historic construction drawings to develop this design. The door shown in Figure 8 was made by a local mill from Douglas fir. The hardware is all stainless steel to minimize maintenance and to extend the serviceable life of the door. As an added weather protection measure, a traditional drip edge has been installed along the bottom of the door to shed water away from the door opening.

The door in Figure 9 is designed to minimize the problems at a lighthouse that does not see regular visitation because of its remote location. Four factors took precedence over historical correctness: weathertightness, ventilation, security, and maintenance. The door had

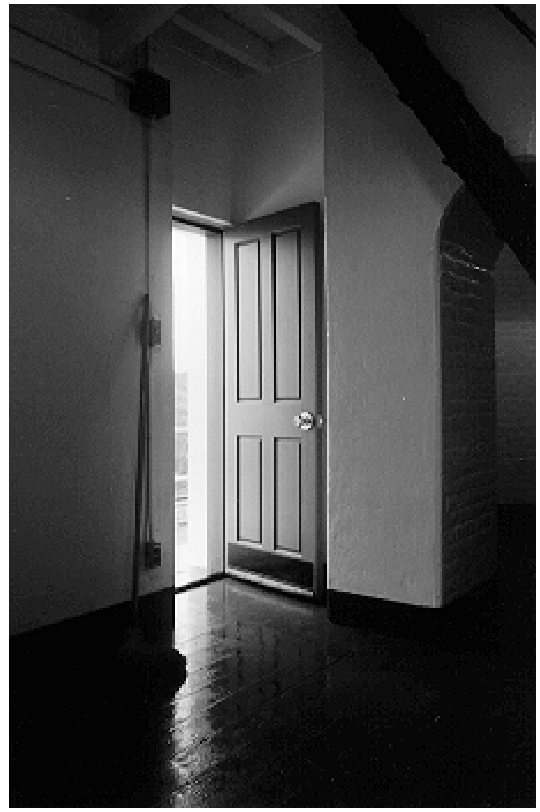


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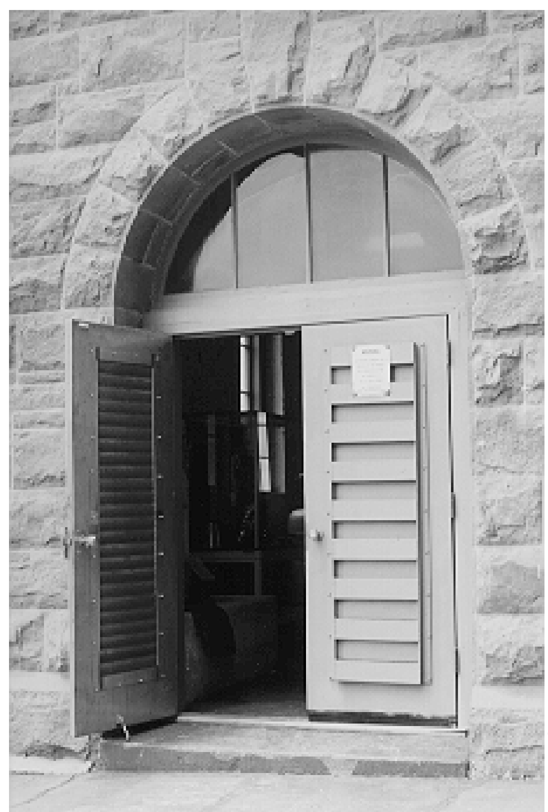
Figure 8.



WPTC photo

Figure 9.

to be weathertight to withstand the seasonal driving rain storms. At the same time the door had to provide adequate ventilation to minimize condensation buildup during hot and cold temperature changes. The door had to be secure because the remote location did not allow for regular security patrols; vandals or trespassers had to be effectively deterred. The rest of the structure required minimal annual maintenance; therefore the door should not require any more than annual routine maintenance.

The solution to the problems associated with the mothballing of this lighthouse was to use high-quality materials and sound design. The doors are made of Type 304 stainless steel. The louvers are baffled to allow for more than adequate air exchange, which will minimize interior condensation buildup, while at the same time preventing water infiltration. The louvers are also screened to prevent animal infiltration. The locks and hinges are also stainless steel to prevent corrosion and ensure long-term use. The installation of this type of door should not permanently affect the historic door frame.

CASE STUDY: St. Simons Island Lighthouse Lantern Glass Replacement

by Paul Neidinger, WPTC

The USCG Civil Engineering Unit (CEU) Miami maintains a classical third-order Fresnel lens as an active aid to navigation at St. Simons Island Light Station, Georgia. This lighthouse and associated keeper's quarters serve as the museum space and offices for the Coastal Georgia Historical Society and Museum of Coastal History. The third-order Fresnel lens remains in excellent condition because of the attention it receives by dedicated USCG Aid to Navigation Team (ANT) and CEU Miami personnel, as well as USCG auxiliarists. The NPS Williamsport Preservation Training Center was contracted through the CEU Miami to rehabilitate the lantern glass. This project had a limited budget and a tight schedule for completion.

Scope of Work

The scope of the project required the replacement of the 10 damaged wire-glass panels with laminated glass and contemporary glazing materials. The treatment had to incorporate and maintain the historic lantern elements as well as the character and appearance of the historic glazing system. Design development was aided by consultation with onsite USCG personnel and auxiliarists who perform routine maintenance on the lighthouse, along with examination of existing conditions. The project goal was not only to replace the lantern glass but to develop an incremental program of historic lantern preservation where the lantern glass and lantern frame members would be repaired without the need for a complete lantern restoration. Ultimately, this implementation strategy could be replicated by USCG ANT Teams on other lanterns, thus helping to preserve lighthouse lanterns without a complete costly restoration.

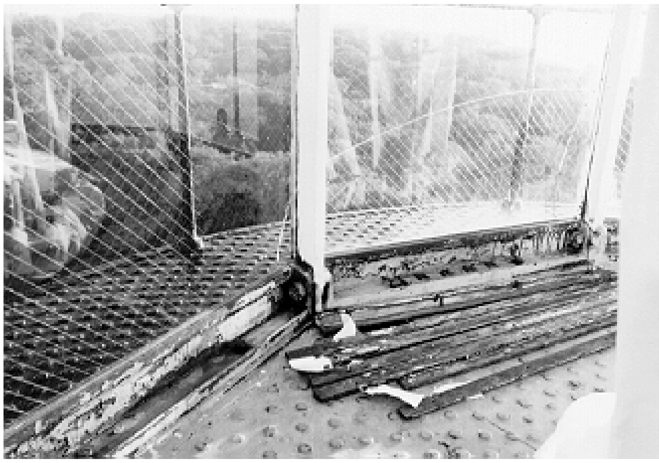


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Figure 10. Oblique of the interior of the lantern room with exterior bronze astragals stored in the foreground before cleaning and removal of the extent wire-glass panels.

The scope of work was limited to the lantern glass panel system, which included the restoration of the bronze mullions, astragals, and screws, as well as preservation of the cast-iron posts. Elements contributing to the deterioration of the lantern glass included inoperative bronze sill vents and a potentially blocked ventilator ball; both of this conditions elevated moisture levels in the lantern, which in turn caused premature corrosion of any exposed metal surfaces. (These deficiencies should be addressed as a separate preservation treatment.)

The rehabilitation of the cast-iron posts was limited to treatment of the exposed surfaces with rust inhibiting coatings. Any further treatment would have required the removal of the bronze sill and cast-iron deck. The perimeters of the treatment were

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Figure 11. The extent of the damage to the cast-iron column through exfoliation can be seen in profile after the removal of loose rust and the lower bronze mullion.

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Figure 12. Detail of the bronze sill when the lower mullion is removed; the fastener is re-tapped and the cast-iron column is treated with a rust converter. Note that the bronze astragals have been cleaned and are ready to accept the glazing system.

carefully decided before the start of the work; any other approach could have easily led to a total restoration rather than an incremental weatherization of the lantern by replacing and upgrading the lantern glass panel system.

Logistical Challenges

The scope of the preservation work was limited to that which could be done under typical conditions experienced by ANT Teams. The treatments were carried out using simple handtools, eliminating the cost of specialty items. The focal plane of the St. Simons Island Lighthouse is 102 feet above sea level. Regulations defined by the Occupational Safety and Health Administration (OSHA) for fall protection were adhered to throughout the project. Each worker wore a standard body harness that was tied off to a secured location inside the lighthouse. This system provided protection for the worker while maximizing his mobility around the lantern and gallery deck. When removing coatings that contained lead, the procedures outlined by the OSHA Interim Final Rule for Lead Exposure in the Construction Industry were followed to avoid contaminating the lantern room and tower, which is visited by tourists year round.

The area of operation, the lantern room, allowed for minimal movement. Access to, or movement of, glass had to be in limited tolerances, sometimes as little as a one-inch clearance, especially at the stairway from the service room of the lower gallery

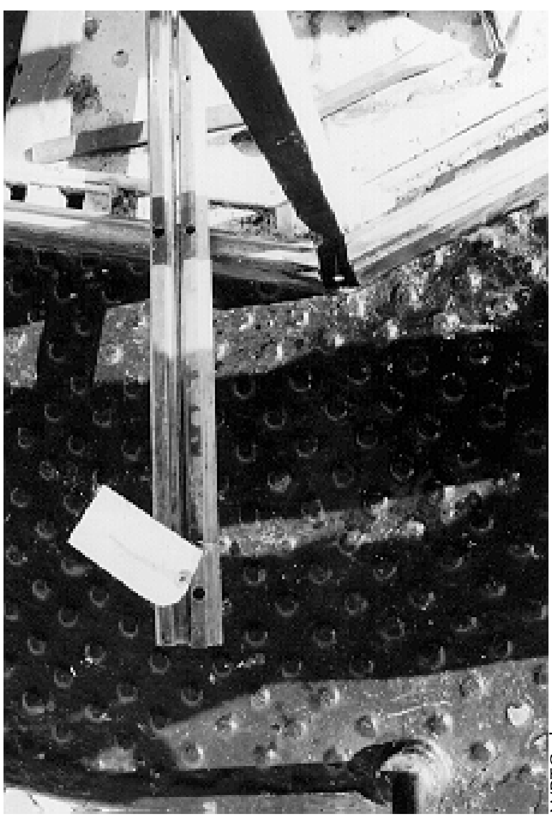

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Figure 13. This detail of the bronze sill shows the location of the new lower fastener before its removal and resetting with the lower bronze mullion.

WPTC photo

Figure 14. Following placement of the restored bronze mullion, the fenestration is ready to receive the new glazing system.

Figure 15. The polybutyl sealant tape was placed on all receiving surfaces on the plane of the interior face of the glass and on the inside faces of the exterior astragals.

Figure 16. This detail shows the new glazing system in place with associated cast-iron post and bronze sill available to receive additional cleaning and paint removal.

deck to the lantern room deck. With this in mind, each piece of glass was carefully hand carried and stored in the service room below the lantern room until it was time for installation. During the project, the lens was covered to protect it from damage.

Foul weather could have delayed the work on this structure; however, during the course of the preservation work, the only weather problem was cold temperature. High wind gusts did limit work for one day.

Astragal and Fastener Removal

Each glass panel relies on six bronze astragals fastened to bronze mullions with pan-headed bronze screws. The historic astragal screws did not have standard size threads. Machining new screws to fit extant threads in the bronze astragals and cast-iron posts was not an option because of prohibitive costs and lack of adequate lead time in the project schedule for machining. Making the extant threads of bronze astragals and cast-iron posts match contemporary thread sizes would have involved extensive field resizing and tapping of extant holes.

Since most of the fasteners remained in excellent condition and could be easily reused if extracted carefully, extant fasteners were retained and restored, and replacement screws installed only when necessary. Broken fasteners were usually limited to the lower sill astragal where the bronze screws, astragals, and sill experienced the most galvanic reaction with the cast-iron gallery deck. Since this area is directly below the lantern roof drip line, the rain splash-back readily supported the galvanic action because of the constant presence of water (the electrolyte). Typical damage to fasteners was fracturing of the pan head from the screw shaft. The shaft itself was typically heavily corroded in situ, making removal difficult or impossible without grinding the extant burr flush; drilling out the screw shaft followed with care taken

WPTC photo

Figure 17. Note the detailing of the finished exterior astragal in place and the polybutyl sealant tape visible in profile.

not to impact the receiving threads. During reinstallation, the reusable screws were strategically placed, thus distributing the missing screw locations to less critical locations in the lantern. This allowed placement of historic screws in critical areas while awaiting the manufacture of replica screws.

The astragals were heavily coated with linseed-oil-based putty, hard putty, paint, and polyurethane sealant. In spite of this, the base metal on all the astragals and associated bronze elements showed very little signs of deterioration. There was slight pitting of the surface of the astragals at the headers and sill. All of the astragals retained planing marks and identification numbers from their manufacture.

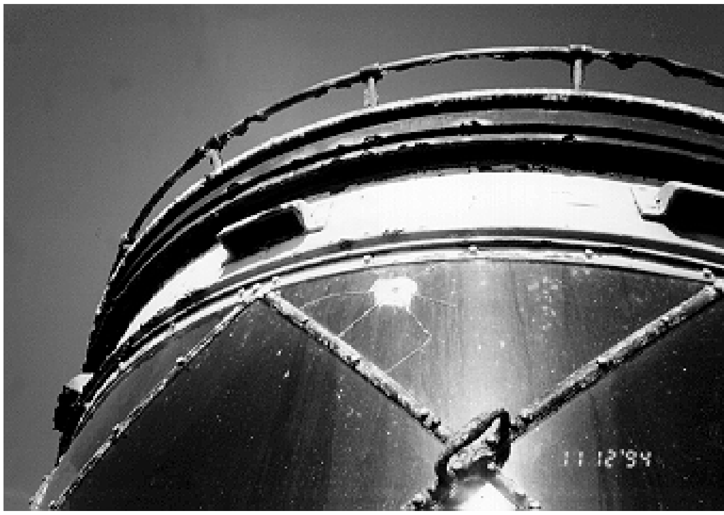
Glass Removal and Replacement

Damage to the lantern glass was the result of exfoliation or 'rust-jacking' on every exterior face of the cast-iron columns. Each bronze mullion fastened to the cast-iron column had been deformed, with complete failure of the lowest fastener. The exfoliating rust exerted forces on all ten glass panels, breaking the ¼-inch-thick annealed wire glass across the base of the panels. This allowed for water infiltration and endangered the classical lens. The glass was removed in two to three panels at a time so that rehabilitation of the fasteners and bronze mullions could be completed before placement of the new glazing system.

One of the first comments heard after completion of the lantern glass replacement was that the lighthouse projected a brighter and clearer beam of light. During the replacement of the storm panels, USCG auxiliarists received a complaint from a local pilot that the light on the lighthouse tower was going out. This impression resulted from the distortion between the new and old glass and plexiglas that was temporarily installed in the open panel locations while the work was in progress.

The success of this project indicates that preservation of historic lighthouse lantern glass can be achieved in an incremental manner, working under a reduced budget while being in full compliance with the *Secretary of the Interior's Standards for Treatment of Historic Properties* and with regulations defined by the Occupational Safety and Health Administration.

CASE STUDY: Rehabilitation of Anacapa Island Lighthouse



USCG photo

Figure 18. Close-up of the deteriorated conditions of the Anacapa Island Lighthouse before rehabilitation.

by CWO3 Wayne Truax (formerly with CEU Oakland)

Anacapa Lighthouse is located on Anacapa Island, 11 miles off the coast of Port Hueneme, California. It was built in 1932 and was the last lighthouse built by the U.S. Lighthouse Service. Until the 1995-1996 Coast Guard rehabilitation, Anacapa Lighthouse had never undergone any major repairs.

Determining the Scope of Work

Civil Engineering Unit Oakland's Facility Inspection Team originally identified the need for this rehabilitation during an inspection of the lighthouse in 1992. The entire lighthouse was in such poor condition that it was labeled the worst lighthouse on the West Coast (see Figure 18). The inspection team initiated the paperwork that identified both the need for the rehabilitation and funds. Although most large Coast Guard projects normally take five years before being funded, Anacapa was in such poor condition that it was given a high priority; design work started within two years. In late 1994 the architect assigned to the project made his first site visit. The architect determined that the best way to repair the badly deteriorated cast-iron lantern house was to remove it from the concrete tower via heavy-lift helicopter and transport it to the mainland for overhaul. Further investigation, however, disclosed several insurmountable obstacles; he was forced to consider a more conventional but far from easy onsite rehabilitation of the entire lighthouse. The following scope of work was identified and budgeted for $325,000:

(a) Replace all broken lantern room glass.

(b) Replace the missing vent ball with a new fully functional replica cast 304 stainless steel (S/S) vent ball.

(c) Replace the severely deteriorated ladder rails on the lantern room roof with 304 S/S replicas.

(d) Restore the solid bronze lantern room door and lock to a fully operational condition.

(e) Abate all lead and asbestos coatings.

(f) Restore all vents to an operational condition.

(g) Repair all decorative concrete details and structural concrete.

(h) Replace all missing ventilation hoods and covers with historically accurate replacement parts fabricated from 304 S/S.

(i) Replace the severely deteriorated galvanized iron windows with new galvanized steel windows.

(j) Install new coatings that require minimal maintenance by Coast Guard personnel.

Logistics and Planning

Because Anacapa Island is home to several endangered bird species, the rehabilitation had to take place during the winter months and be completed before the late spring nesting season. The island is difficult to access; all materials had to be brought to and from the site either by boat or helicopter. Transportation costs ranged from $300 per hour for a barge to $500 per hour for helicopter services. Constant changing winter weather, rain, fog, 100 m.p.h. winds, and rough sea conditions often ruined the best logistical plans. Some days the landing area for the boat would go from calm at 6:00 a.m. to very rough by 10:00 a.m., forcing the contractor's supply boat to turn around and wait another day. Other days the wind was so strong that materials could not be delivered by boat or helicopter. Since the island was so remote, the workers had no choice but to stay on the island for four days at a time and work ten-hour days.

Everyone learned very early just how quickly work could come to a stop when equipment broke down or supplies failed to arrive. There was no quick run to the parts store or to the equipment rental center. A breakdown was either corrected onsite or the work was delayed until parts could be brought out to fix it. Sometimes the work could be postponed until another scheduled supply run was made to the island. There were a few times, however, when the helicopter had to fly out with nothing but a small part because no one else was coming out to the island for several days. A simple $30 item then cost the contractor $250 in helicopter services.

Dissimilar Metals

Anacapa Lighthouse did not have damage caused by dissimilar metals; however, a lot of new stainless steel (S/S) replacement parts were introduced and care taken to prevent any future problems. A barrier was applied in all cases where S/S was attached to the cast-iron or bronze areas of the lantern. S/S fasteners were coated with a modern anti-seize compound to prevent galvanic reaction and to take the place of the original white lead. A thick gasket made of roofing felt and coated with a silicone caulk was installed between the new S/S vents, vent hoods, and cast-iron lanternhouse walls (see Figures 19 and 20). The gasket was made from 15 lb. roofing felt which was inexpensive, easy to apply, and did not crush when the vents were bolted in place. Installing the new S/S ladder rail ring stanchions required a two-step process. First a coat of primer was applied and allowed to dry. Then a heavy coat of primer was applied and the stanchions were installed while the primer was still wet creating a watertight seal. This last step was needed because when the original stanchions were removed, a heavy coat of red lead was found sealing the joint.

On previous lighthouse rehabilitations broken bolts were replaced with 316 S/S to avoid painting the nonferrous metal; however, on more recent rehabilitations, a bolt

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Figure 19 (left). Buildup of rust in parapet wall vents.

Figure 20 (above). The finished vent installation: 15-lb. roofing felt was placed between the bronze vent grill and the cast-iron parapet wall.

that would develop a green patina to match the mullions was selected. All the broken bronze bolts on the lantern window mullions were replaced with marine grade silicone bronze instead of stainless steel. Use of the silicone bronze bolts also removed any concerns of dissimilar metal reaction, and they are equal in strength to stainless steel for this application.

Enclosure, Hazardous Waste Containment, Prep Methods, and Painting

The rehabilitation took place during the winter months, so no repair work could begin until the contractor completed an enclosure around the lighthouse. The enclosure served several purposes: containment of hazardous materials; protection of workers from severe weather; and a dry environment for the repair, prepping, and painting of the lighthouse. The first step in building the enclosure was the erecting of a scaffolding completely around the 30-foot concrete tower. Next was a weathertight plywood enclosure for the cast-iron lantern, complete with pitched roof to shed heavy rain. The final step was sealing the scaffolding in heavy shrink wrap to provide weather protection and containment of any hazardous materials (see Figures 21 and 22). The entire enclosure phase of the project took two weeks because of difficulties in handling the plywood and applying the shrink wrap in high winds. After the enclosure was complete, all deteriorated metal pieces that were scheduled to be replaced and did not require abrasive blasting were removed.

Because the lantern was sealed off from the rest of the tower while being blasted, chemical stripping of the paint could take place on the exterior tower walls and

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Figure 21. View of the plywood lantern enclosure and scaffolding.

USCG photo

Figure 22. View of the lighthouse scaffolding covered with shrink wrap to contain all hazardous materials and protect workers from severe weather.

windows. The stripper was water-based and applied by brush and airless sprayer. After soaking for at least 1 1/2 hours, it was scraped off (see Figure 23). The stripped area was then neutralized with water and finished with power sanding where necessary. The interior lead-painted walls which were originally only to be lightly scraped and painted were causing problems. The paint was so old and brittle it continually flaked off. The abatement contractor asked for a change order to completely remove the paint because the current finished product was proving to be unacceptable. Chemical stripping of the interior walls had been selected over light blasting to save on the costs of transporting more blasting media to the island. Air-driven needle gun scalers using low pressure air, however, proved to be a more cost-effective method. The paint was so brittle, it shattered when struck by the needles, leaving the concrete virtually paint free (see Figure 24). There was no damage to the concrete and only lead-paint chips were left to be swept up and disposed of. This method could not be used on the exterior concrete because of the 3/8-inch white mortar skim coat that had been applied as a finish coat when the light was built in 1932.

After the interior walls were complete, the cast-iron spiral staircase was the last item to be abated. The blaster started at the top floor of the lantern and backed his way to the front doors. This process took three days and prevented any other interior work from taking place because of the dust. After the blasting was complete, the entire structure was swept and vacuumed before being rinsed down to remove the remaining dust. The water did cause flash rusting on the newly blasted cast-iron staircase but that was expected and did not pose a problem (see Figure 25). All surfaces were then wire brushed, prepped, and primed by a three-man team who only prepped what they could prime within an hour. Although the primer used was designed for use over flash-rust, we did not want to chance a coating failure.

The following generic paint systems were selected based on durability, performance over minimally prepared surfaces, non-toxicity, and permeability:

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Figure 23. The water-based paint stripper was very effective in removing the many layers of paint from the exterior of the tower.

(1) Exterior ferrous metalwork: moisture cure urethane primer and top coat*

(2) Interior ferrous metalwork: moisture cure urethane primer and top coat*

(3) Exterior masonry and concrete: elastomeric acrylic, coarse texture

(4) Interior masonry: 'breathable' acrylic, minimum 55% permeability

*This product will cure in 99% humidity; this facilitated application during fog and misting weather.

USCG photo

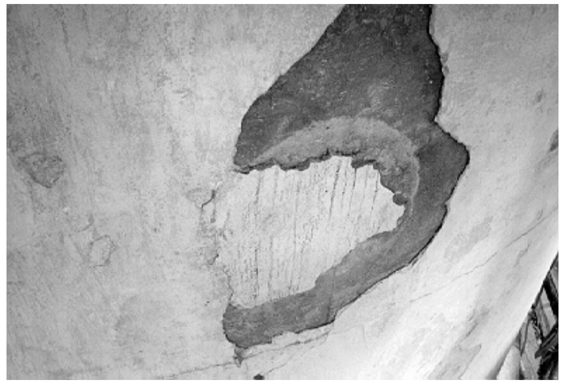
Figure 24. The interior paint was effectively removed using needle gun scalers, without damaging the concrete as evidenced by the visible impressions of the formwork boards.

USCG photo

Figure 25. After the cast-iron stairs were blast-cleaned, they were rinsed to remove all traces of lead dust; flash rust immediately formed (as seen in this photo). Before painting, this light rust was removed with wire brushes.

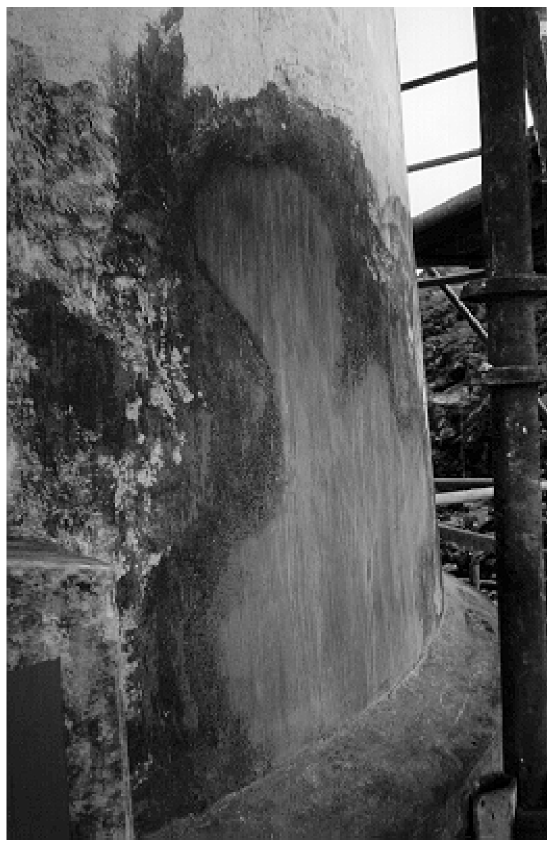
Concrete Repair

The 3/8-inch white mortar finish coat that had been applied over the exterior concrete when the light was built in 1932 was not identified in any of the original drawings. As a result, no one looked during the work site visit for signs of delamination. After the scaffolding was in place, however, several areas were found to be loose between the 10- and 30-foot elevations. The foreman became concerned that other unidentified delaminated areas would fall out after the job was complete and ruin his work. The foreman inspected the entire tower and found an additional 100 square feet of delaminated mortar. After receiving approval to repair any bad mortar, he personally chipped away all the loose mortar and applied a two-part masonry patch material. The repair work was of such high quality that the patches were unnoticeable when the tower was repainted (see Figures 26 and 27).



USCG photo

Figure 26. Once the scaffolding was erected, areas of the delaminated white mortar finish coat were removed.



USCG photo

Figure 27. The areas where the loose mortar finish coat was removed were repaired with a two-part mortar patch. The final texture on the patch was tooled to match the historic wall surface. The patch was completely invisible after the tower was painted.

Of the 12 tower windows, 8 required extensive exterior concrete repairs. Rusted rebar had spalled the concrete and caused severe damage. The old rebar was removed, new holes drilled and the new rebar epoxy injected in place. The rebar was then covered, packed, and reshaped with a two-part Sika Flex product.

One major area of concern was the concrete gallery deck located outside the lantern. This deck had considerable damage in two areas without any evidence of the cause. The outer rebar showed signs of corrosion but the damage went 18 to 24 inches deeper into the concrete. Since freezing was not an issue, the cause of the damage was at first unknown. Closer examination revealed signs of an explosion inside the concrete, and we noticed bolt patterns for two old antenna mounts directly above the area. We determined lightning to be the cause. There was no practical way to dig out the

USCG photo

Figure 28. Close-up of the damaged concrete gallery deck after the loose concrete has been removed and before the damaged concrete was repaired using pressure-injected epoxy grout.

broken concrete; the project was already over budget. We decided to do a pressurized epoxy injection and fill all the voids. The area was prepped and pumped full. The outer three inches were left unfilled so the two-part mortar patching compound could be used to restore the damaged area (see Figures 29 and 30).

USCG photo

Figure 29. The first application of the mortar patch material to the damaged concrete.

USCG photo

Figure 30. The finished concrete repair is virtually invisible after the surface has been painted.

USCG photo

Figure 31. Close-up of the finished metal work on the lantern.

USCG photo

Figure 32. View of the finished lantern

USCG photo

Figure 33. Point Bonita Lighthouse before rehabilitation; note missing gallery deck and holes below between the bottom of the lantern glass and top of the service room wall.

CASE STUDY: Rehabilitation of Point Bonita Light Station

by CWO3 Wayne Truax, USCG (formerly with CEU Oakland)

The original Point Bonita Lighthouse was built in 1855 on a cliff top in the Marin headlands 260 feet above the water. Within a few years of operation it became obvious that the light was too high and frequently blocked by the San Francisco fog. In 1877, a lower site on the point was chosen for a new lighthouse which reused the existing lantern and watch room.

Determining the Scope of Work

The poor condition of Point Bonita was first noted by the Officer in Charge of the San Francisco Aids to Navigation Team (ANT). His request prompted a site visit to Point Bonita in January 1993 to conduct a facility assessment and provide advice on how to repair the structure (see Figure 33). The original plan was to stop the water from entering the lighthouse and let Civil Engineering Unit (CEU) Oakland do the overall renovation in a couple years. But further investigation indicated the need for more immediate repairs, using self help-funding and the ANT personnel. The project soon grew into a full renovation that took six months and $75,000 to complete.

Researching Historic Details

In researching the history of Point Bonita, none of the books mentioned that the lantern on the current lighthouse was from the original lighthouse. Files at CEU Oakland had only site drawings describing the relocation of the lighthouse. Hundreds of copies of other 19th-century lighthouse drawings were available, but very little on Point Bonita. The Coast Guard Historian in Washington located two 1950s black-and-white photos that provided clear details of the awnings, storm doors, and gallery deck around the lantern that were removed in the early 1960s.

A lot of questions remained unanswered. The original 1855 Point Bonita watchroom, as in most lighthouses, was entered through the floor. The current watch room is entered through the side via a ladder from the first floor bunk room into the weather shelter on the southern roof. One door leads to the watch room and the other leads to the roof. Another problem was that the southern roof had at one time been completely covered by a large observation station. The lookout room had large, tinted green, plate-glass windows on three sides and electronic equipment installed. Was the ladder from the sitting room to the roof added; was the weather shelter even original? To compound problems, no original drawings of the current lighthouse were found.

In the process of moving files in the bottom floor at CEU, 12 file drawers and several boxes of microfilm were found. The drawers contained microfilm with drawings of almost every lighthouse on the west coast. The Point Bonita file, unfortunately, was missing. A check of all lighthouse files with a "B" in their name revealed the missing 1877 Point Bonita drawings, filed under Point Blunt. These drawings removed all doubt concerning the original historic features and made the restoration possible. During that same week, files of old black-and-white pictures were found in a cabinet. The Point Bonita file was full of pictures from the 1800s to modern day. There were pictures of the light after construction, as well as demolition photos of the exterior gallery deck and pictures of the now-removed observation room.

The old black-and-white pictures as well as the original drawings provided a strong base to work with, but not all the dimensions were clear or listed. Facilities assessments visits to several lighthouses built in the late 1800s helped. A visit to Cape Disappointment Lighthouse in Washington was most useful. Cape Disappointment and the original Point Bonita Lighthouses were both built in the mid 1850s and had the same style lantern, as well as the unique eagle-head downspouts for the roof gutters. Although Cape Disappointment was a larger first-order lantern and Point Bonita a second order, many of the details and dimensions were the same. The Cape Disappointment visit provided measurements, construction details, and close-up photos for later work at Point Bonita.

Gallery Deck Restoration

Investigative demolition followed. The original gallery deck had been removed in the 1960s, but no details were available on how it was performed. First removed was the fiberglass cloth that sealed the watchroom panels to the lantern room and covered the areas of the original gallery deck brackets. Fortunately, the old brackets had been cut off above the wide base flange with a torch, leaving the tenons from the original brackets intact inside the cast-iron lantern frame (see Figures 34 and 36). Removal of the remaining tenons from the frame and fabrication of new gallery deck brackets duplicating the originals proved impractical because the tenons were rusted tight and pinned in place. The tenon was therefore used as an anchor. The old base flange flush with the frame was cut using a portable metal-cutting bandsaw and the area ground flush. A special jig was designed for the magnetic drill press; two holes were then drilled and tapped directly between each set of tenons (see Figures 35, 36, and 37). A one-inch-thick mild steel mounting plate consisting of two recessed bolt holes and four tapped holes was then put in place. (304 S/S might have been an even better choice; the mild steel is holding up well, but may become a maintenance problem if the lighthouse isn't properly maintained.) The two recessed holes allowed the plate to be bolted to the lantern frame and the new bracket bolted directly over the two base bolts. The area beneath the plate was covered with a 1/8-inch layer of Belzona Metal filler to ensure there would be no voids and to act as a leveling compound (see Figure 38). The bolts as well as the plate were covered with a releasing compound (Vaseline)

USCG photo

Figure 34. Close-up showing what remained after the gallery deck brackets were cut off with a torch. Note the heavy rust and paint failure caused by exposure.

and then slowly tightened until the plate was plumb. The Belzona was then allowed to dry before all excess Belzona was ground off (see Figure 39). This procedure worked very well and took no more than three days to accomplish. The base plates were then primed, painted, and caulked before being torqued in place.

The new gallery deck brackets were constructed of 3/4- and 3/8-inch steel plate welded and fabricated to match the original cast-iron brackets details. (This is another area where 304 S/S might have been better.) The stanchions were made of 1-inch 304 S/S round stock and 1-inch 316 S/S bolts. The bolts had a 1-inch diameter and 1/4-inch-deep recess machined in the head to ensure the bolts were properly aligned during welding. Custom 1-inch 316 S/S acorn nuts were then purchased to secure the stanchion to the brackets and the handrails. With the brackets and stanchions in place, the 3/8-inch flat bar handrails were then drilled, scribed, and fitted (see Figure 40).

Figure 35. Jig used to bore holes in the gallery bracket tenons.

Figure 36. View of the gallery bracket tenons after the holes have been drilled. The tenon on the right connected to the exterior gallery; the tenon on the left is part of the interior gallery deck bracket. The ‘v’ that has been stamped in the end of the left tenon is an assembly identification mark.

USCG photos

Figure 37. After drilling, threads were cut into each hole using a hand-operated tap.

USCG photo

Figure 38. To provide a plumb mounting surface for the gallery deck, each mounting surface was covered with Belzona (a two-part metal paste); then the mounting plates were installed and tightened until they were plumb. The excess Belzona can be seen oozing near the middle of the plate.

The hard part was laying out the new gallery deck. One 3-foot section of 1/4-inch-thick hard board was laid out at a time. Each section was different and had to be custom fitted. The completed templates were then taken to the Coast Guard Industrial Metal Fabrication Shop and used to lay out the new 3/8-inch 6061 aluminum diamond-plate gallery deck. Once completed, the new gallery deck sections were brought back to the lighthouse for final drilling, fitting, and painting. (The aluminum is working well here, with no signs of dissimilar metals reacting. S/S diamond plate, might however, avoid any future problems (see Figure 41).)

The final installation of the gallery deck required the use of an impregnated felt tape between the dissimilar metals to avoid galvanic reaction. All hardware was also coated with anti-seize compound before being installed. The choice of aluminum was based on cost and the knowledge that when properly installed, it will function very well with other materials. In an effort to ensure that the structure has a long life, however, dissimilar metals should be avoided. Not everyone who does maintenance

USCG photo

USCG photo

Figure 39 (left). View of the mounting surface after the Belzona had cured and the mounting plate had been removed. The ‘knobs’ or protrusions on the surface are where the Belzona was squeezed through the holes in the mounting plate. These were ground off along with the excess Belzona that squeezed out around the plate.

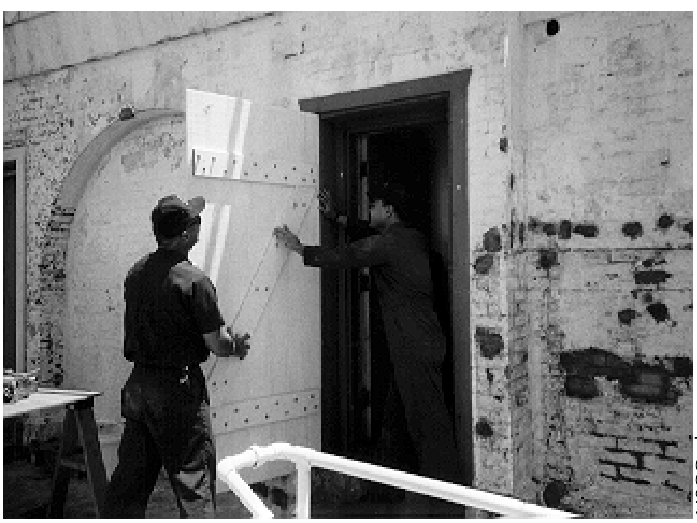
Figure 40 (above). The new gallery deck brackets after installation.

USCG photo

Figure 41. Final fitting and installation of the new aluminum deck plate.

USCG photo

Figure 42. View of the Point Bonita Lighthouse after the gallery deck replacement.



USCG photo

Figure 43. Installation of the new exterior wood storm door.

on lighthouses understands dissimilar metals or even how to ensure that materials are properly reinstalled (see Figure 42).

Awnings and Exterior Doors

The exterior copper awnings were easy to duplicate and relocate. The historic black-and-white photos provided close-up views, and the outlines of the original awnings were still visible. A sheet-metal shop reproduced the awnings based on dimensions and the old photo. The wall anchors should have had S/S hardware. This is minor item and can be easily corrected with new anchors.

The exterior storm doors were also easy to duplicate. The pictures were clear and showed one door open and one closed. Both exterior doors were made of 1- by 6-inch tongue-and-groove redwood and fastened together using S/S carriage bolts, nuts, and washers. After the doors were test fitted, they were disassembled, primed, painted, and reassembled. These doors have held up extremely well and have given no trouble (see Figure 43).

USCG photo

Figure 44. *Before the rehabilitation*. Note the doors at the watch room. A new louvered panel will be installed for added ventilation.

CASE STUDY: Rehabilitation of Point Conception Light Station

by Judd Janes, USCG Architect, formerly with CEU Oakland

In 1995 the U.S. Coast Guard completed a major six-month rehabilitation of Point Conception Light Station located near Lompoc, California. The historic lighthouse was built in 1882 and contains its original first-order Fresnel lens. Other than being automated in 1973, the only major structural rehabilitation to the light station was in 1947. The goals of the project were to stop the water infiltration and condensation that was accelerating the deterioration of the lighthouse; repair all damaged structural members; and install new work that would require minimal maintenance by Coast Guard personnel. The major structural work on the lantern involved complete reconstruction of the lantern gallery deck, the lantern ladder, ladder rails, cornice, and sill castings as well as installation of a natural ventilation system to reduce condensation. The extremely remote location (approximately 30 miles off the highway and down 198 steep wooden stairs) as well as constant exposure to heavy rains and over 100-m.p.h. winds made the project extremely challenging.

Determining the Scope of Work

The main factors in determining the scope of work were overall project cost and preservation of the integrity of the structure. The original budget was set at $250,000. Given the severity of the deterioration, the primary focus was to complete all major structural repairs to the lantern, as well as minor painting and repairs to the masonry tower and fog signal building.

Selection of the Contractor

A contractor was chosen under the 8A Small Business Administration Program who was experienced in previous Coast Guard light station rehabilitation projects.

This particular method of government contracting involves negotiating the final cost of the job with one known contractor, rather than a low bid situation with many unknown contractors. In California, the Coast Guard has been able to use the 8A program effectively to achieve a more consistent quality of workmanship. Light station projects require very specialized skills, so selecting a qualified contractor is crucial. Prequalification criteria should require knowledge of the *Secretary of the Interior's Standards for Rehabilitation*, and include the minimum following experience:

- Logistic planning and mobilization for remote sites.
- Rigging and scaffolding around towers and historic structures.
- Asbestos and lead paint removal on historic structures.
- Masonry and concrete repair on historic structures.
- Fabrication and repair of historic metalwork.
- Applying industrial paint systems in marine environments.

Logistical Planning

Because of difficult site accessibility, all materials were airlifted to and from the light station via helicopter. Since helicopter services are very costly, staging had to be planned very carefully. A complete inventory of materials and equipment was required in advance to determine size and weight of the lifts. The proximity of the staging area to the lighthouse was also critical given the radius of the blades and the local wind conditions. No electrical, telephone, water, or sanitary facilities were available for use onsite. Basically, everything had to be brought in and out by the contractor. The lighthouse is 198 wooden steps down from the parking lot; the nearest town is located over 40 miles away, down one-lane roads following hairpin turns and steep ravines. The contractor's mobilization costs, as well as personal travel and per diem costs, significantly increased normal project costs.

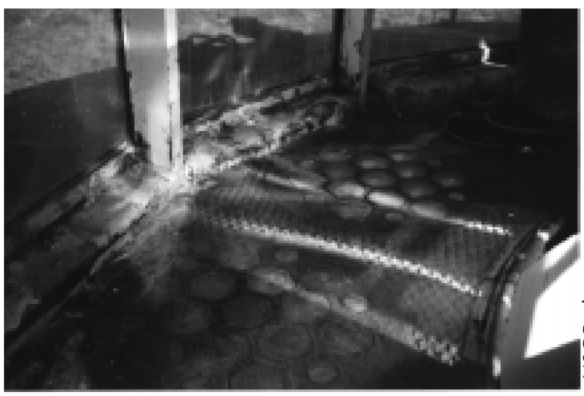

USCG photo

Figure 45. *Staging the work.* Note the temporary location of the auxiliary light on the fog signal building chimney.

The weather was also a major factor on this project. Heavy fog, rain and plus-100-m.p.h. winds, common at Point Conception, caused many delays in the construction schedule and created extremely difficult working conditions. At one point during the project,

USCG photo

Figure 46. *Lighthouse lantern before rehabilitation.* Note the missing ladder rails and the severe rust on the lantern cornice and lower watch room panels. The badly spalled concrete gallery deck was installed in 1947 and is not original.



USCG photo

Figure 47. *Lantern room before rehabilitation.* Note the lower sill channels filled with concrete. This shortsighted 'repair' method blocked the ventilators and caused condensation to spill out on the deck, effecting rust and further damages below.

USCG photo

Figure 48. *Reconstructing the cornice.* The cornice plates were removed to expose the corroded cast-iron brackets and top channels. New brackets were cast in bronze, and the top sill channels were fabricated in stainless steel. Note the plywood 'curtain' erected for weather protection and shoring the lantern roof during reconstruction.

heavy rain washed out portions of the road, which cut off access for over a week. A special plywood 'curtain' was erected in the lantern room with clamps to protect the classical lens from the weather and shore up the lantern structure during reconstruction.

Dissimilar Metals

Although surface rusting was the main problem at the lantern, some of the deterioration was caused by galvanic reaction between dissimilar metals. Dissimilar metal problems were eliminated by replacing the original deteriorated cast-iron cornice plates and brackets with copper and bronze. The original copper roof dome was then stripped of its paint and allowed to naturally patina. Besides low maintenance, the other advantages of copper are its flexibility to withstand strong winds, building movement, and wide temperature changes. In other areas, neoprene gaskets, felt or teflon tape, thick epoxy primers, and bituminous paints were used between dissimilar metals to prevent future corrosion.

Preparation Methods and Painting Systems

The Secretary of the Interior's guidelines mandate using the "gentlest method possible" in preparing surfaces on historic buildings. This generally means hand tool preparation, non-caustic strippers, and low pressure blasting. Given the lead paint and heavy rust on the lantern, a variety of methods were used including chemical stripping, hand tool preparation, power tool preparation, and grit blasting. The existing exterior paint on the masonry tower and fog signal building was in

Figure 49. *Reconstructing the gallery deck.* After removing the existing concrete, remnants of the original cast-iron deck were found.

Figure 50. *Lantern cornice after rehabilitation.* Replacing the original steel cornice plates with copper eliminated the dissimilar metals problem.

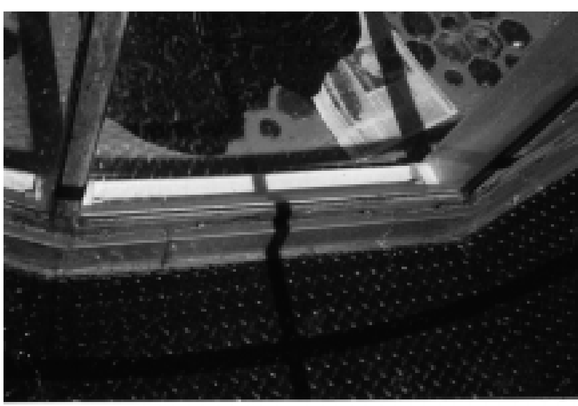


Figure 51. *Lantern galley deck after rehabilitation.* The new gallery deck was fabricated with stainless steel diamond plate and carefully flashed with copper at the lantern room. The interior lower sill channels were rebuilt to catch condensation from the glass.

good condition and required only hand scraping and washing to remove the loose paint, dirt, salt, and contaminants. The interior masonry walls of the tower were stripped of loose paint and repainted with a 'breathable' acrylic paint to alleviate hydrostatic pressure. Paint removal on lighthouses can be a costly operation because it often involves lead or asbestos abatement. This can necessitate using specialized safety equipment and tools, as well as hiring certified abatement contractors and installing very expensive containment systems.

Painting in this harsh marine environment was a difficult challenge. To avoid flash rusting, a rust inhibitor was applied immediately after preparing the surfaces. Even with this painstaking effort, bleeding rust was a constant problem that often led to rework. Under these conditions, it is unrealistic to expect any paint system to last beyond five years without some maintenance. The following generic paint systems were selected based on durability, performance over minimally prepared surfaces, non-toxicity, and permeability:

- Exterior ferrous metalwork: synthetic rust inhibitor, inorganic zinc primer (new metal only), high-solids self-priming epoxy, aliphatic polyurethane topcoat.
- Interior ferrous metalwork: waterborne epoxy primer, epoxy acrylic topcoat.
- Exterior masonry and concrete: elastomeric acrylic, coarse texture.
- Interior masonry: 'breathable' acrylic, minimum 55% permeability.

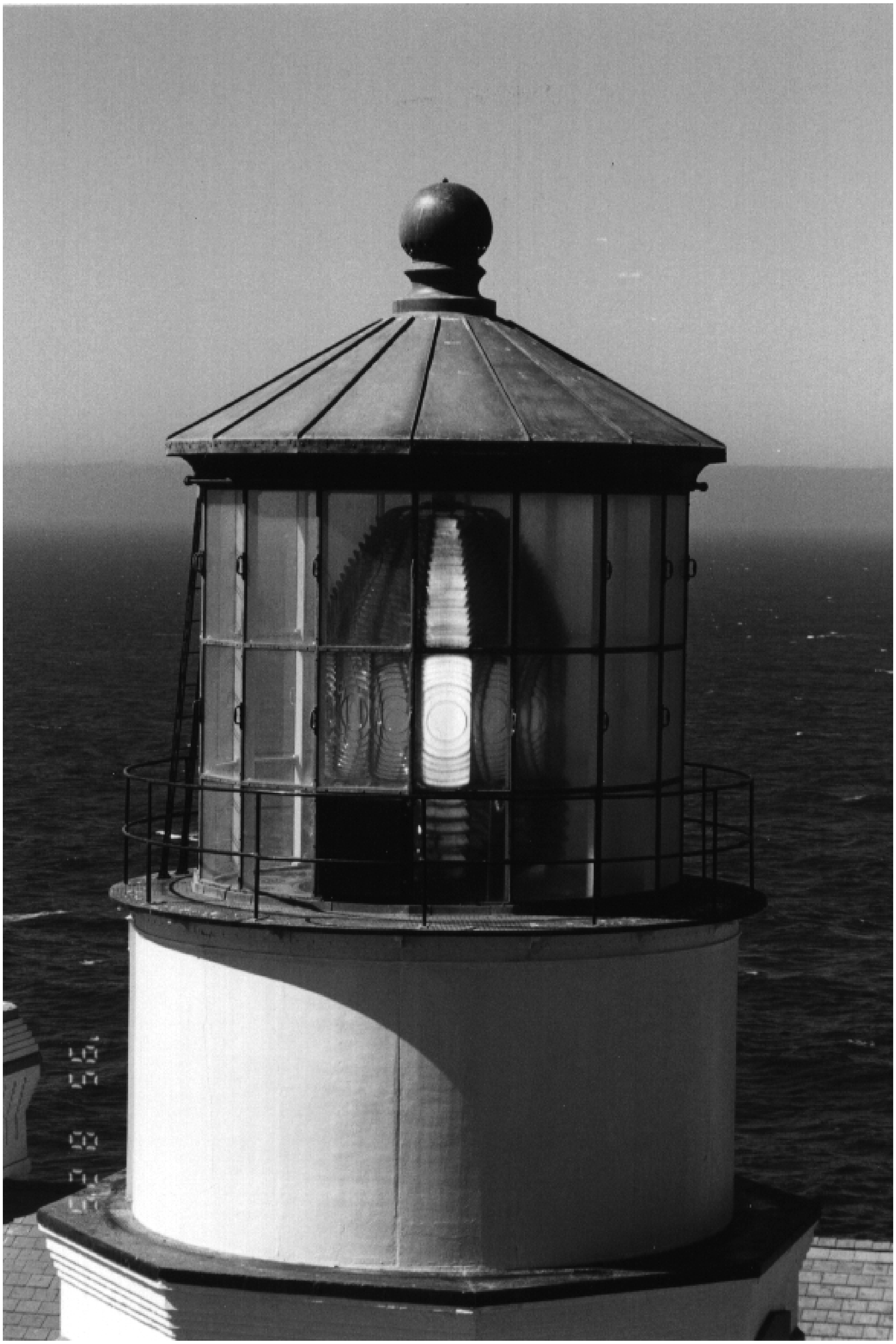
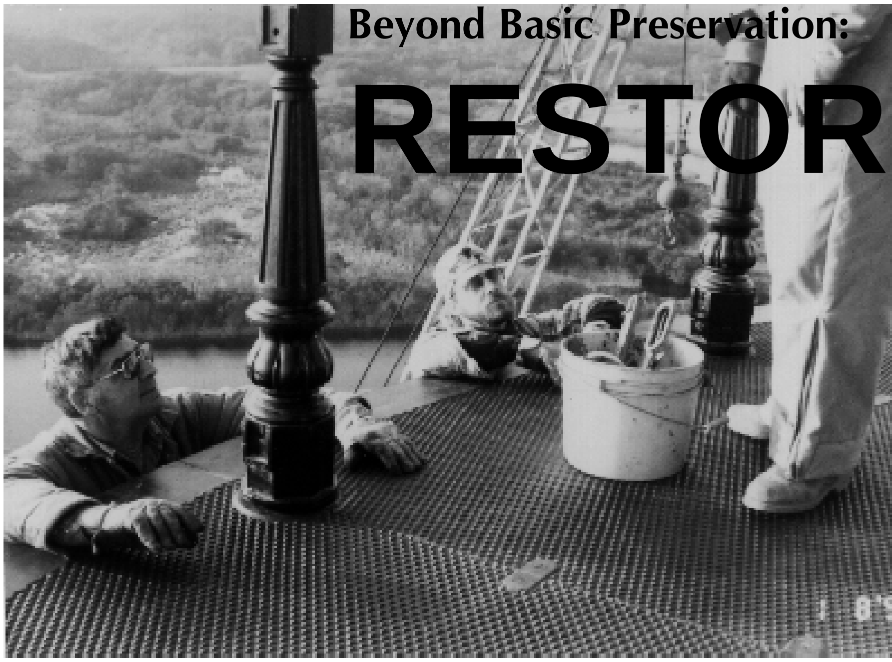


Figure 52. *Light tower lantern after rehabilitation.* The nonferrous metalwork at the lantern room is left unpainted and allowed to naturally patina, thus saving maintenance costs.

Beyond Basic Preservation: RESTORATION



International Chimney Corporation (ICC) photo

Figure 1. New ornate cast-iron handrail posts were recast and installed on the new gallery deck as part of a restoration at Cape Hatteras Lighthouse, Buxton, North Carolina.

Restoration is defined as the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by removing features from other periods in its history and reconstructing missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project.

Restoration as a Treatment: When the property's design, architectural, or historical significance during a particular period of time outweighs the potential loss of extant materials, features, spaces, and finishes that characterize other historical periods; when there is substantial physical and documentary evidence for the work; and when contemporary alterations and additions are not planned, *restoration* may be considered as a treatment. Before undertaking work, a particular period of time, i.e., the restoration period, should be selected and justified, and a documentation plan for *restoration* developed.

Standards for Restoration

- Use the property as it was historically or find a new use that reflects the property's restoration period.
- Remove features from other periods, but document them first.
- Stabilize, consolidate, and conserve features from the restoration period.
- Replace a severely deteriorated feature from the restoration period with a matching feature (substitute materials may be used).
- Replace missing features from the restoration period based on documentation and physical evidence. Do not make changes that mix periods and falsify history.
- Do not execute a design that was never built.

This is a summary of the central ideals of the *Restoration* treatment standards excerpted from the *CRM* article, "Historic Preservation Treatment: Toward a Common Language" by Kay Weeks (Vol 19, No. 1, 1996, p. 34).

CASE STUDY: Restoration of the Cape May Lighthouse

by Joseph Jakubik, International Chimney Corporation

The Mid Atlantic Center for the Arts, Inc., a non-profit organization, obtained funding for the restoration of the Cape May Lighthouse, Cape May, New Jersey, through local donations, the state of New Jersey, a grant from the National Trust for Historic Preservation, and the Department of Transportation through the Intermodal Surface Transportation Efficiency Act. The architect selected for the project was Watson & Henry Associates, of Bridgeton, New Jersey, a veteran of other lighthouse projects, including the Barnegat Lighthouse. The restoration required a variety of disciplines including masonry restoration, painting, machining, steel and cast-iron fabrications, copper work, and glazing. Plans were completed and the project sent out to bid to a list of pre-qualified bidders. International Chimney Corporation (ICC) of Buffalo, New York, was selected.

The project was started in January 1994 with the mobilization of ICC's crew and equipment, including a GCI 5400 tower crane, capable of 325-foot tip height. The first step was to remove the lantern from the tower of the lighthouse. The plane of separation was to have been at the sill connection to the lantern deck, allowing removal of the lantern intact and relocation to ICC's facility in Buffalo, New York. After carefully removing the many layers of paint and corrosion around the connection, it was discovered that the stiles that supported the window wall and roof were embedded into the masonry at least 4 feet below the level of the lantern deck. Shop restoration of the entire lantern room was not possible.

ICC photo

ICC photo

Figure 2 (left). Condition of the bronze sill sitting on the lantern deck inside the lantern room. The sill is wedged between two vertical cast-iron stiles, which are anchored into the masonry below.

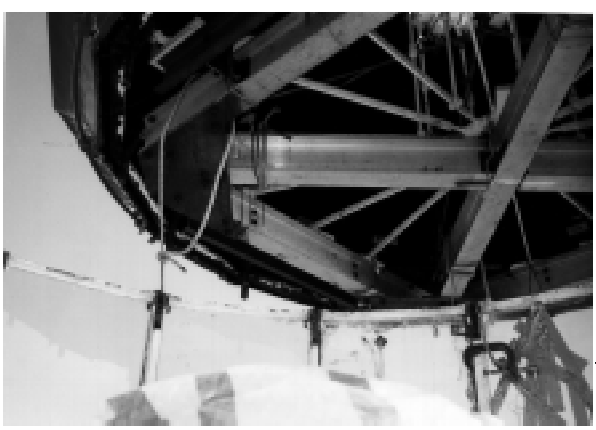
Figure 3 (above). Horizontal mullions run in between the stiles and serve to keep the stiles straight and frame the individual pieces of glass. Before restoration, the mullions and sills had been bolted in place over 140 years.

Necessity is truly the mother of invention. The job was replanned to include disassembly of the roof only and rework of the lantern in the field. A large temporary steel enclosure, affectionately referred to as the 'soup can', was fabricated to fit over the window wall system and allow craftsmen to work in relative comfort during the coldest winter in Cape May history. The temporary steel enclosure, designed to accommodate both interior lighting and ventilation, was installed on a system of cantilevered beams that concentrated the load on the brick column of the tower. A lifting jig was designed and installed underneath the roof, and the roof was disconnected from the window wall system.

ICC photo

Figure 4. The first step in removing the roof was to take off the vent ball. The vent ball not only serves as a lightning rod but also provides ventilation to the glass in the lantern room, limiting condensation.

Even on a calm day, the winds at 195 feet above sea level blow at a constant 25 to 30 miles per hour. The roof was carefully removed, lowered to grade, and transported to Buffalo, New York, for repair. True restoration work could now begin. The window wall system was carefully dismantled, all components tagged, wrapped, and sent to Buffalo for restoration. Imagine the difficulty of trying to free over 200 bolted connections that have been corroded by a moist salt air environment for over 140 years. Many of the replacement fasteners had to accommodate thread designs used in the 19th century.



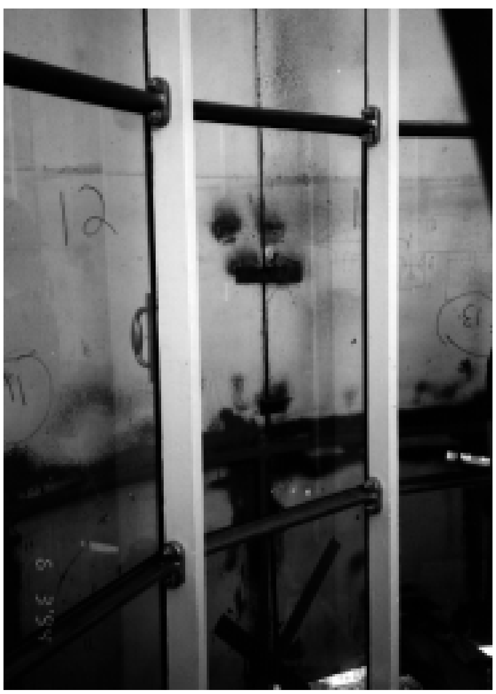
ICC photo

Figure 5. As the roof is being removed from the lighthouse, the tie rod system, supported by ICC's aluminum roofing frame, is visible. This frame was designed to fully support the roof and alleviate any stress or strain on the roof during the lift. Protruding down from the roof are the ends of the rafters which connect to the top of the stiles.

In Buffalo, extreme care was required to restore the roof without compromising dimensional integrity of the 16 tie rods and 16 roof rafters. The roof would be reinstalled in the same position, mating in 16 individual points, bolting together in 48 individual machined holes. The roof measured over 13 feet in diameter; restoration included replacement of the original cornice brackets that held the roof to the window wall and kept the shape of the copper. A 1/16-inch difference at each location would add up to a one inch deviation, preventing the roof from fitting.

ICC photo

Figure 6. During the restoration, this 'Campbell Soup Can' was installed over the lantern room in order to protect restoration efforts from the environment.



ICC photo

Figure 7. Inside the lantern room, the mullions have been reworked and reattached to the stiles. New stainless steel bolts have been used to prevent corrosion and teflon tape has the used as a gasket between the bronze and the cast iron. Teflon washers also separate the bronze from the stainless steel bolt.

Back at the lighthouse, attention was turned to stripping all existing paint from the lighthouse, exposing the original color; meticulously repairing all damaged or eroded mortar joints; and repainting the structure with a special coating that matched the original color of the lighthouse.

In June 1994, all preparations were complete for reassembly of the lantern room and roof system. The matched, marked pieces were carefully refitted with new stainless-steel hardware and teflon tape which acts as an isolator between the dissimilar bronze and cast-iron metals. In the 19th century, little was known about the chemical reaction between dissimilar metals. When a copper-based metal is placed in contact with a ferrous-based metal, an anode-cathode reaction occurs, similar to a battery. This changes the molecular structure of the ferrous metal, causing corrosion.

ICC photo

Figure 8. New hand holds were replicated to replace missing pieces. These exactly match the originals.

ICC photo

Figure 9. The refurbished roof is replaced on the lantern room. The fit is almost exact.

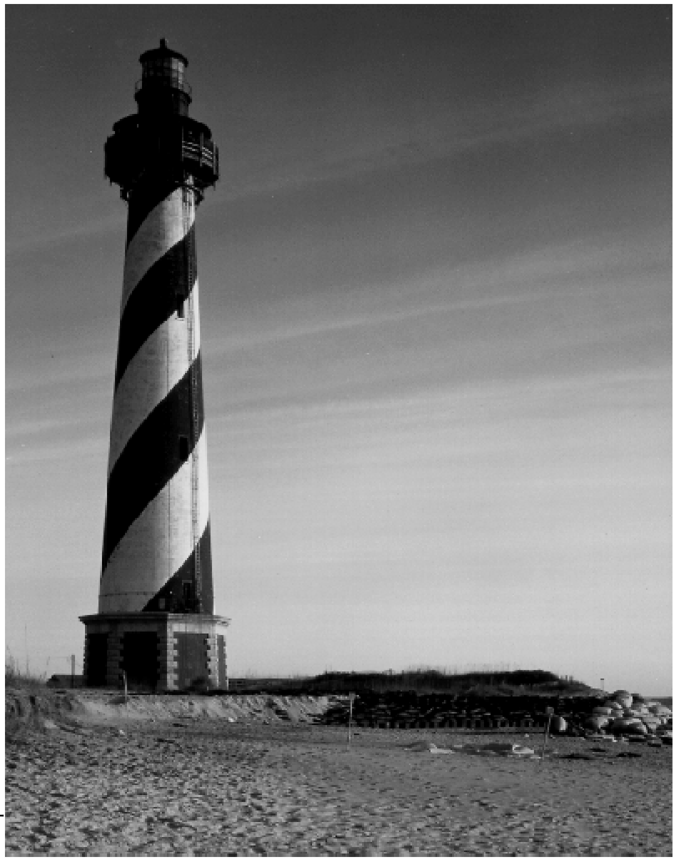
New safety glass was installed on the window wall system, and the 'soup can' was no longer needed. A relatively calm wind would be required to remove the enclosure and set down the newly refurbished roof. On the June 4, 1994, conditions appeared favorable. The enclosure was lifted and, for the first time in five months, the efforts of the craftsmen were revealed. The newly lacquered bronze mullions, glazing bars, and sills gleamed in the bright early summer sun.

Meticulous preparations were made on the ground and in the air for the lift. The refurbished roof was centered as close as possible to the center line of the lighthouse and turned to allow for the proper fit in its original position. ICC's craftsmen were perched on ladders waiting for the roof to be hoisted. When all was ready, the signal was given and the lift began. The roof was centered above the window wall and began its descent. The result was anticlimactic. The roof came down exactly into position as if sucked in by a giant magnet. The major portion of the restoration was complete.

ICC photo

Figure 10. All glass is now in place and final preparations are made for the reopening.

CASE STUDY: Restoration of Cape Hatteras Lighthouse



ICC photo

Figure 11. The Cape Hatteras Lighthouse during restoration.

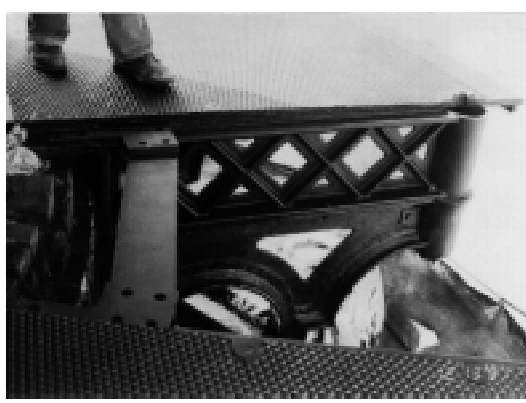
by Joseph Jakubik,
International Chimney Corporation

Late in 1990, International Chimney Corporation (ICC) was chosen by the National Park Service to perform the preservation work on the Cape Hatteras Lighthouse in the Cape Hatteras National Seashore in North Carolina. The Cape Hatteras Lighthouse has served a section of the Atlantic ocean known as the "Grave Yard of the Atlantic" since the 1870s, but the elements and corrosive seawater had taken their toll. The first-order Cape Hatteras Lighthouse is the tallest brick lighthouse in the U.S. The ornate, victorian-gothic, cast-iron construction of the interior and exterior iron work was produced after the Civil War, when foundries, no longer producing cannons for the war, focused their efforts on producing ornate cast-iron architecture and hardware.

The time for replacement of these ornate castings was at hand. The large gallery deck, with its ornate tread patterns and hand rail had deteriorated to the point where it was no longer feasible to repair. On the interior of the lighthouse, many of the steps of

ICC photo

Figure 12. Some brackets were so deteriorated that they were totally exposed to the elements.



ICC photo

Figure 13. After the most severely deteriorated portion of the brackets were removed, new cast-iron pieces were made and installed; and new deck plates installed.

ICC photo

Figure 14. The handrail assembly has been removed and the ornate cast-iron post is ready for removal.

ICC photo

Figure 15. A replica handrail is installed.

the long spiral staircase were cracked, weathered, or deteriorated. The ornate cast-iron sections at the landings, complete with handrails would no longer protect climbers on their way up or down the tower.

The restoration was scheduled to begin early in 1991 with the mobilization of International Chimney's GCI crane, capable of 325-foot tip height. At the last moment, however, a barge ran into the Bonner Bridge over the Oregon Inlet. While ferries were immediately put into service to accommodate traffic, the crane was too large to move to the site. The schedule was adjusted to accommodate the change in plans, and the interior lighthouse work started first.

The first step was to remove the deteriorated castings of the spiral staircase and return them to Buffalo to be used as a guide for the new castings. The spiral staircase is built so that each step supports the remainder of the staircase to the next landing. To remove the deteriorated pieces, the stairways were supported, both above and below the removal area, by steel cables from the landings above.

The ornate cast-iron pieces of handrail were carefully removed, examined, and shipped back to Buffalo. The service room windows were severely deteriorated, with only portions of the existing cast pieces available for a guide to new work. These were removed, new pieces cast, and custom-fit to the window openings. New 1-inch safety glass was installed in the service room.

The lantern room in the lighthouse was severely corroded as a result of interaction between dissimilar metals. All components were removed, reworked, and replaced, and new 5/16-inch laminated safety glass installed.

ICC photo

Figure 16. At the base of the brackets, the cast-iron belt course is removed, exposing deteriorated masonry below.

ICC photo

Figure 17. The cast-iron belt courses are repinned to new masonry beneath.

When repairs were completed to the Bonner Bridge, exterior work could begin. A 7-foot-wide, circular work deck was placed below the large gallery deck. This afforded access to the complete hand rail system and deck plates. The hand rail components were carefully removed, as were the deck plates. The surviving pieces of deck plate were so deteriorated that accurate measurements could not be made. The deck was recalculated and a template made of the theoretical size and shape of the new deck plates. This was custom-fitted to each individual bracket, revealing that the lighthouse was slightly out of round. Measurements were taken for each individual section, which required custom casting, machining, and fitting of each individual section of plate. The brackets supporting the plate were reworked, and individual components recast. The belt course holding the brackets together below was removed, the masonry underneath repinned, and the cast belt course reinstalled. Deteriorated masonry was carefully cut out and repainted, as was the granite pedestal at the base.

All doors were refurbished and the seven landing windows replaced. The project took approximately a year and a half, and was completed before a hurricane hit in the fall of 1993. The hurricane damaged (by impact) three of the windows in the lantern room and tore off a portion of the hand rail of the lantern deck. (This hand rail was not replaced under the original contract). ICC performed the needed repairs in the spring of 1994, and once again the lighthouse opened to the general public.

Beyond Basic Preservation:

Related Activities

NMI photo

Figure 1. A historic site managed by the Minnesota Historical Society, most of the buildings (including one of the keepers' quarters shown above) at Split Rock Light Station are interpreted to the period of its construction in 1909.

Examples of Adaptive Use/ Rehabilitation

B&Bs/Inns: A few light stations have been successfully adapted into bed-and-breakfasts by both private owners and nonprofits. Examples include East Brothers Island Light Station in San Francisco Bay, California; Saugerties Light on the Hudson River, New York; Selkirk Light Station in Pulaski, New York; and Isle Au Haut Light Station near Isle Au Haut, Maine. At Rose Island Light Station off Newport, Rhode Island, guests are expected to perform daily chores including noting the weather; keeping a lookout for boating emergencies; and working on maintenance tasks such as painting, washing windows, and making minor repairs.

Youth Hostels: Point Montara and Pigeon Point Light Stations[1] are located just 28 miles apart along the northern coast of California. Both light stations serve as youth hostels established through a cooperative agreement with the U.S. Coast Guard via the state of California. In 1978 the California legislature appropriated $1.9 million for the California State Park System's Coast Hostel Facilities Plan in response to a preliminary state plan developed in 1975. Five vacant and abandoned lighthouses were considered as suitable hostel sites. Point Montara and Pigeon Point were in the best shape and were recommended for development into part of a chain of hostels along the California coastline.

Because of initial leasing difficulties, these lighthouse projects took nearly three years to launch. Initially the Coast Guard, which owned the lighthouses, would offer only a short-term lease to the state. Without a long-term lease, the state was hesitant to invest large amounts of money for renovations. The Coast Guard allowed "interim use" of Point Montara and Pigeon Point until a long-term lease finally was approved. Under the interim agreement, the state began renovations and issued

[1] Historic Hostels Report (Washington, DC, American Youth Hostels, n.d.).

NMI photo

Figure 2. East Brother Island Light Station in San Francisco Bay, California, serves both as an active aid to navigation and bed-and-breakfast.

operating permits to the Golden Gate Council of American Youth Hostels (AYH).

The two hostels were developed almost simultaneously. Several organizations contributed to the restoration of both lighthouses, including the California Department of Parks and Recreation, which contributed in excess of $100,000 as part of its pilot coastal hostel project. The California Coastal Conservancy contributed to the hostels as part of its program to promote low-cost visitor access to the state's increasingly expensive and exclusive coastline.

Restoration of the Point Montara Lighthouse and the conversion of both the vandalized Victorian-style and modern light keeper's quarters into a 35-bed hostel facility cost more than $100,000. AYH volunteers and staff contributed $45,000 worth of labor and time. Renovations for Pigeon Point were also heavily dependent upon volunteer labor, cash contributions, and donated supplies. One of the major private contributors to this project was Crocker Bank with a $25,000 grant.

The two lighthouses attract more than 23,000 overnight guests each year. Park rangers and hostel managers cooperate to offer educational programs on the coastal environment for guests. If AYH had not occupied these lighthouses 15 years ago, the station buildings other than the towers which were maintained by the Coast Guard, would be largely in ruins today. Occupancy generally precludes damage to a historic structure. AYH is not only preserving historic sites, but enabling young people to learn about them and use them.

Tibbetts Point Lighthouse, New York, and the former lifesaving station on Nantucket, Massachusetts, are other AYH projects which have preserved historic Coast Guard structures.

Figure 3. At Bodie Island Light Station in Cape Hatteras National Seashore, North Carolina, the tower holds an active aid to navigation while the keeper's quarters serves as a museum.

Museums: Numerous light stations have been adapted into museums or interpretive centers. A few examples include: Montauk Point Light Station in Montauk, New York; Split Rock Light Station on Lake Superior, Minnesota; Hereford Inlet Light Station in North Wildwood, New Jersey; St. Augustine Light Station in St. Augustine, Florida; Key West Light Station in Key West, Florida; and St. Simons Island Light Station in St. Simons, Georgia. In some cases the keeper's quarters have been turned into residences for caretakers while the rest of the station such as the tower and oil house are open to the public. Currituck Beach Light Station in Corolla, North Carolina, is an example. In some cases museums, particularly maritime museums, have obtained lighthouses and moved them to their museum to serve as exhibits. Examples include Calvert Marine Museum's Drum Point Lighthouse in Solomons, Maryland; Chesapeake Bay Maritime Museum's Hooper Strait Lighthouse in St. Michaels, Maryland; and Shelburne Museum's Colchester Reef Lighthouse in Shelburne, Vermont.

Parks: Many light stations are located within the boundaries of national, state, and local parks. In some parks, buildings at the light station are accessible to the public, in others, only the grounds. A few of the better-known examples of lighthouses in parks would be Cape Hatteras Light Station in Cape Hatteras National Seashore along the Outer Banks of North Carolina; West Quoddy Head Light Station in Quoddy Head State Park, near Lubec, Maine; and Point Reyes Light Station in Point Reyes National Seashore, in California.

Research/educational facilities: Because of their location in wildlife refuges and nature preserves, a few light stations have served as research facilities. At the Lime Kiln Light Station on San Juan Island in Washington, the tower serves as a whale research lab. Matinicus Rock Light Station off Rockland,

Figure 4. At the Lime Kiln Light Station on San Juan Island in Washington, the tower serves as a whale research lab while the keepers' quarters serve as park housing. The station is located within Lime Kiln State Park

Maine, is used as research headquarters by Audubon biologists.

Private homes: Numerous light station keeper's quarters have been converted to private homes. Examples include New Dorp (Swash Channel Range Rear) Light on Staten Island, New York; Chapel Hill Range Rear Light in Leonardo, New Jersey; Roanoke River Lighthouse in Edenton, North Carolina; Mendota (Bete Grise) Lighthouse on Lake Superior, Michigan; and Grand Island North Light Station in Grand Island, Michigan. Other keeper's quarters are used for housing of park employees or military personnel when located in or near a park or military installation. Examples include Point Fermin Lighthouse at Point Fermin, California; Yerba Buena Island Light near San Francisco, California; Egmont Key Light Station on Egmont Key, Florida; and Prospect Harbor Point

SIDEBAR: To Relight or not to Relight?

Lighthouses which are decommissioned by the Coast Guard are no longer considered active aids to navigation although at least 17 privately owned lighthouses serve as private aids to navigation. Many restoration projects call for relighting the lighthouse. Before such efforts can be undertaken certain procedures must be followed so that new lights do not interfere with present navigation lighting systems. Coordination with the Coast Guard is absolutely necessary and approval not guaranteed. Furthermore, a new liability may result. If your light was being used for navigational purposes and for whatever reason it failed, the owners of a vessel which suffered damage as a consequence of this failure could sue. This is a major burden for a fledgling lighthouse preservation organization. The Coast Guard is protected from liability under the Federal Torts Claim Act which limits their responsibility, but this does not apply to non-Coast Guard operated aids to navigation. For stations where the Coast Guard still maintains the light, even when the light tower is under non-public ownership, the Federal Torts Claim Act is still in force. While such an arrangement may be considered an advantage, the Coast Guard will require access to the lantern room and they usually want this area restricted from public access with special exceptions. In an attempt to obtain protection from the Federal Torts Claim Act some organizations such as Friends of Sakonnet Point have attempted to lease back their lighthouse to the Coast Guard for as little as $1.00 per year, while still maintaining responsibility for the maintenance of the structure. But the Coast Guard has declined such offers. Another possible option is to relight the tower so that it is visible only from land and not visible from the water, thereby not serving as an active aid to navigation. The Coquille River Lighthouse was relit so that the light could be seen from the town of Bandon but not from the river approach at sea.

Lighthouse in Prospect Harbor, Maine. In some cases keepers quarters are rented out by nonprofit groups to help generate operating and maintenance funds. Examples include Piney Point Light Station, Piney Point, Maryland; and Rose Island Light Station off Newport, Rhode Island.

Miscellaneous adaptations: Many light stations, such as Piedras Blancas Light Station in San Simeon, California, have been turned over to other federal agencies and in this case, used for housing of Fish and Wildlife Service staff. The Army Corps of Engineers allow a local Coast Guard Auxiliary unit to use the keeper's quarters as a meeting and office site at Ontonagon Light Station, Ontonagon, Michigan. Other stations have been turned over to local governments. For example, the engineer's office at Government Island, formerly part of the Minots Light Station, is now used by the Cohasset Harbor Master; the oil house by the Cohasset Sailing Club; and the keeper's quarters turned into efficiency apartments. Perhaps the most unusual adaptation of a lighthouse is that of Tillamook Rock Lighthouse. Located off the coast of Oregon, it is used as a columbarium (repository for the ashes of cremated persons). Oakland Harbor Lighthouse in Oakland, California, was moved to land and turned into “Quinn’s Lighthouse Restaurant.” Though not a lighthouse, the St. Joseph Lighthouse Depot complex is in the process of being turned into a microbrew pub and restaurant.

Interpretation and Public Outreach

A restored light station without interpretation is an artifact with no associated information—very little educational value can be gleaned. There are several ways good interpretation can be added to lighthouses/light stations.

- ***Interpretive panels*** (signage) are the most commonly used method. The advantage is that they are relatively inexpensive to make and have relatively low maintenance cost; interpretive signs can be read at the leisure of the visitor and do not require an individual (paid or volunteer) to be present to provide information orally. Panels placed outside buildings enable visitors who arrive after hours or out of season an opportunity to learn about the property even when closed. The physically impaired, who cannot gain access to some areas can still view photographs of lantern rooms, etc.
- ***Pamphlets, brochures, and published histories*** are another means to educate the public about the property. They can be reproduced rather cheaply, and printing costs might be sponsored by a local bank or business in exchange for a credit line. A keyed map to the property can also serve as a guide to the site. Histories of the property can be published and sold both as an educational outreach tool as well as a fundraiser. Printed materials can be taken home and read at leisure as a post-visit educational tool.
- ***Guided tours*:** Many visitors prefer the personal touch of a tour given by a knowledgeable individual. Properly trained, such tour guides can add life to a site by imparting not only historical facts, but insights into the people who worked and lived there. Many light stations have recreated living and work spaces as they may have appeared at some moment in the past. A tour guide can also keep a watchful eye on small objects which add to the realism of the recreation but might be picked up and handled, damaged, and/or stolen by unsupervised visitors. Some guides dress in keepers' uniforms or other period costumes to add realism to the experience.
- ***Living history/plays:*** Living history programs using actors who portray persons who once lived at the site are another means of interpretation. A play, based on local fact, can create a history of the site which informs the public in an entertaining way. These can be done on- or off-site and may also be used as a way to raise funds for restoration and/or operation of the facility.
- ***Audio/audiovisuals:*** An effective interpretative tool which can stand alone or be used with other educational methods is an audio tour of the site. Numerous companies create and sell the hardware. These options are relatively expensive, but have proven very popular with

Figure 5. Since Split Rock was first accessible by highway in 1924, it has been popular with travelers. Today it continues to draw over 120,000 visitors annually.

CASE STUDY: Interpretation at Split Rock Lighthouse

by Lee Radzak, Historic Site Manager, Split Rock Lighthouse

The keeper finished cranking the 250-pound cast-iron weights up the 40-foot weight-way tube running up through the center of the lighthouse. He removed the crank handle from the clockwork mechanism and pulled a handkerchief from the pocket of his midnight-blue wool uniform coat and wiped a few smears from the polished brass of the lens assembly. As he took a moment to admire the sparkling prisms of the Fresnel lens, he heard strange voices coming up the spiral staircase. An eager family came puffing into the lens room to stare wide-eyed at the glittering four-and-a-half-ton marvel of French technology revolving above them. They then turned to look out the window at Lake Superior 160 feet below. "Welcome to Split Rock Lighthouse," said the keeper. "I'll bet you're wondering why the lighthouse service would build a lighthouse way up on top of this cliff."

This scene could have occurred in the late 1920s as easily as the late 1990s. The major difference is that in the 1990s the 'keeper' is a historic site interpreter employed by the Minnesota Historical Society; in the 1920s he was a light keeper employed by the U.S. Lighthouse Service. In 1939, when the U.S. Coast Guard assumed responsibility for the country's aids to navigation, they said that Split Rock was "one of the most frequently visited lighthouses in the United States." Although Split Rock Lighthouse was decommissioned as a navigational aid in 1969, visitors continued to stop at the popular landmark. The light station is now a Minnesota state historic site; preservation and interpretation are the responsibility of the Minnesota Historical Society (MHS). Visitation peaked in 1989, the year of the U.S. Lighthouse Service bicentennial, at 212,000.

With the well-preserved light station and with public interest and high attendance a given, Split Rock was a natural addition to the Minnesota historic site system in 1976. As with all open-air museums, the interpretive program at Split Rock has been developed and customized to fit specific conditions. Visitation patterns, audience interest and demographics, the physical environment of the site, availability of historical and research information, and, of course, financial resources, are among some of the considerations when developing an interpretive plan for any historic site.

For an interpretive program to succeed at a historic lighthouse, the administrating entity needs to have a clear vision of what they want visitors to understand about the site. This can only be done by first developing a concise interpretive plan that sets objectives for what story is to be told at the site and how it is told. At Split Rock we were very fortunate: when we began research on the site in the mid-1970s, several sons and daughters of the early keepers who actually lived at the light station in the 1910s, 1920s, and 1930s were helpful in providing us with firsthand information about life at Split Rock. They were a very valuable source of anecdotal information, and even provided written records and early photographs of life at the lighthouse. This information was corroborated by the official logs for the light station that were kept by the keepers. From these, and other archival sources, we had an excellent base of information on which to build an interpretive program, as well as good documentation for restoration projects that have returned the buildings and grounds to their pre-1924 appearance.

Solid and well-researched documentation provides the fuel that will drive a successful interpretive program. For us, the next step was to look at the resources we had and how best to present them to the visiting public. First, an interpretive staff manual was developed. While this is updated annually, the basic information it contains gives an interpreter a primer in interpretive technique, as well as an in-depth background on the history of lighthouses, shipping, the Great Lakes, the U.S. Lighthouse Service, and Split Rock Lighthouse. A detailed interpretive outline for guided tours is included along with expected learner outcomes for each of the stations on a tour. In-depth staff training, though expensive, is key to an effective and successful interpretive program. Each spring we hold two full days of training for our entire staff of 22 to 24 employees. Morning meetings are held with the daily staff each day of the season and monthly full-staff meetings are held throughout the summer.

After being open to the public for 20 years, Split Rock Lighthouse historic site's program evolved into one that gives visitors a variety of options for touring the light station. For the casual visitors, self-guiding brochures allow them to see the buildings and grounds of the light station at their own pace and to interact with stationed interpreters as they wish. Hour-long guided tours are led by site interpreters to seven tour stations, or stops, on the light station. Beginning in the 1996 season the decision was made to expand our interpretive program to include costumed interpreters who role-play either the keepers or their wives from the time period of 1925. We chose that year as our target date for the first-person interpretation because it was the first year that the new highway allowed tourist access to the isolated light station. The head light keeper's log for 1925 shows that the isolated life at Split Rock was changing and that they were dealing with tourist traffic on a regular basis. The highway is a perfect interpretive vehicle or bridge—excuse the puns—between that historical period and our interpretation of it. Visitors today still travel the same road to see the same lighthouse, and they can relate to the historical connection between the keepers and their early visitors.

Adding a living history component to an interpretive program can greatly enrich a visitor's appreciation and understanding of a site and its content. If done right, first-person, costumed role playing can be very effective, but much care, forethought, and a high level of commitment to accuracy must accompany the decision. At Split Rock we had used costumed role playing to a limited extent for special events; because of the very positive reception, we have now incorporated it into our daily interpretation. Every day, three of our seven interpreters portray either a keeper or a wife of a keeper. A limitation at our site is that only the lighthouse and one of the three light keeper's dwellings is totally restored to the 1920s, complete with period furnishings, so the first-person interpretation is most effective inside these two buildings.

If living history is to be done with any credibility, it has to be done right. That means no short cuts on costuming—accurate period keepers' uniforms and 1920s vintage reproduction house dresses for the women. Only appropriate jewelry and hairstyles are to be worn by costumed interpreters, and even the language and slang that the interpreters use while in character have to fit the 1920s. Since the time period that we are interpreting at Split Rock is relatively recent we do not portray actual keepers and family members that served at Split Rock Lighthouse. Instead, through extensive research, we have developed composite characters based on historical information specific to Split Rock and generic qualities shared by light keepers of the time period. Biographical histories were developed for six fictional characters so that an interpreter is assigned a specific character to portray for the day.

At Split Rock we use a form of modified first-person that we call "my eyes, your eyes." If a visitor asks the 'keeper' why there is a light bulb in the lens, the interpreter will drop character enough to say, "To your eyes you see a 1000-watt light bulb that was used after the light station was electrified in 1940, but to my eyes in 1925 it looks like an incandescent oil vapor lamp that burns kerosene." Some living history sites and interpreters around the country would not break character if the site were burning down around them. This works well for some sites that have been able to totally reconstruct a given time period. At Split Rock we have found that many visitors have needs and questions that just can not be answered from a different time period and are confused, intimidated, or just plain do not want to play along. For them we will briefly break character if it will help interpret a concept or idea to them.

Additional methods of interpretation can strengthen a site's program. Each historic site has a unique story that should be told. There are many very good methods to facilitate the telling of that story. Interpretive film can be an extremely effective way to illustrate facts and ideas that can be difficult to convey in other ways. In our 22

Figure 6. The lives of the Split Rock light keepers and their families in the 1920s is portrayed for visitors to the site by present-day interpretive staff and volunteers.

minute film, *Split Rock Light: Tribute to the Age of Steel*, which is shown every half-hour in our history center theater, we show how the growth of the Minnesota iron ranges led to the need for lighthouses on Lake Superior. In an age when every visitor relates to video, even short two or three minute audiovisual programs can be effective, and made inexpensively. A museum store should also act to support and reinforce the interpretive theme of the site. Selling either period craft items appropriate to the theme of the site or publications will take the visitor one step further in their understanding of the site. An exhibit gallery can allow for interactive displays or describe or illustrate ideas that supplement what the interpreters are able to do.

While all of these interpretive tools are a means to an end—understanding the past—we will never be able to recreate history in any kind of literal way. In some ways interpreting the past is like the mariner studying the lighthouse from the watery distance. Using his compass and his light list for guidance, and hoping that fog or a snow squall do not alter the beam, he keeps an eye to his one true contact with land. The actions of the past are a constant focal point; our interpretations of these actions in the present can affect how clearly we are able to see the past as it truly was.

(References for this case study can be found under the Related Activities portion of the Bibliography in Part V., Resources.)

visitors and make learning easy. Audio tours use hand-held tape decks, radio headsets, and/or telephone stations. Another tool is a well produced audio slide show, tape, or film. A room or portion of a room at the property can be turned into a small theater, used either for an introductory or post visit interpretative show. Cassettes can also be sold to help generate funds. One of the best introductory lighthouse films was created by the Minnesota Historical Society for Split Rock Lighthouse.

CAUTION: All of the above suggestions can be made into excellent interpretive tools, but, 1) the end product will be only as good as the basic research; 2) a poorly researched program or product can be worse than nothing at all. Misinforming the public is worse than not informing them at all. Base research on primary sources and use professionals when possible. Local museums and/or state museum associations may be able to assist in planning and creating a program. The American Association for State and Local History, 530 Church Street, Suite 600, Nashville, TN 37219-2325 (phone 615/255/2971) can also provide assistance. They also have several publications dealing with preservation, local history, and interpretation.

Fundraising Ideas

Montauk Point Lighthouse (New York)

This 108-foot-tall light tower sits on a bluff on the eastern end of Long Island and rises 160 feet above sea level. The U.S. Coast Guard leased the lighthouse and grounds, which include a small museum, to the Montauk Historical Society. To raise funds for the Society's restoration, Arlo Guthrie, a famous American folk singer, has given concerts to benefit the Montauk Point Lighthouse and museum. Proceeds from the concerts have contributed towards measures to control erosion of the shoreline which has threatened the lighthouse since the 1960s.

Anclote Key Lighthouse (Florida)

The Anclote Key "Save the Light" preservation group has similarly raised money. Entertainer Bertie Higgins, known for his hit song "Key Largo," performed a benefit concert in 1994 to help raise public awareness and funds for the restoration of the Anclote Key Lighthouse. He also paid for signs which were erected on the island announcing the preservation efforts for the lighthouse. The Florida poet and songwriter team of Lee Paulet and Betsy Bolger-Paulet performed a benefit concert aboard the Casablanca Cruise Ship in September 1995, also to benefit Anclote Key Lighthouse.

Fire Island Lighthouse (New York)

The Fire Island Lighthouse Preservation Society has successfully completed its 10th annual "Barefoot Black Tie," which includes a buffet dinner, auction/raffle, dancing, and entertainment, all "under the stars" by ticket only (rain or starlight). Over 500 people attended the 1996 event, coming from all over the country and arriving by car, water taxi, and private boat. The King Wellington Calypso Band provided the entertainment appropriately set in front of the lighthouse.

Grand Haven Lighthouse Catwalk (Michigan)

Lighthouse catwalks were constructed to allow the light keepers to safely transit above the long piers (1,000 plus feet) extending into Lake Michigan at Grand Haven, South Haven, St. Josephs, and Manistee, Michigan, as well as Michigan City, Indiana. The catwalks allowed the light keeper to access and tend the pierhead lighthouses by walking 10 to 12 feet above the breaking waves and ice formed during stormy weather and during the winter. Once the lighthouses were automated in the 1960s, however, the catwalks were no longer needed by servicing or maintenance personnel.

The U.S. Coast Guard made plans to demolish the catwalks in 1987 because of their deteriorating condition—caused by ice damage to the iron supporting structure and concrete footings—and missing and rotting wood planking. The catwalks were an "attractive nuisance" to youth who would attempt to climb them even though access to the steps was fenced off and locked. There was a serious concern of possible injuries.

Grand Haven catwalk was originally constructed of wood in 1871. It was replaced by the present iron catwalk with wooden planking in 1922. The catwalk and the two lighthouses it serviced on the Grand Haven pier became landmarks to the tourist community over the years and were even featured on the city's official stationary. Coast Guard officials asked the city if it would take over responsibility for repairing and maintaining the catwalk before drafting plans and specifications for demolition. The city was not in a position at the time to assume responsibility; however, a local citizens' group, Save the Catwalk, Incorporated, was formed on May 22, 1987, for that purpose. The group worked actively with the city and the U.S. Coast Guard to develop an acceptable plan to 1) make repairs to the catwalk under a license from the Coast Guard, and 2) develop a plan (including liability

USCG photo

Figure 7. To raise funds to combat erosion problems at Montauk Point Light Station, Montauk, New York, the Montauk Historical Society sponsors concerts.

NMI photo

Figure 8. As a result of the Mid Atlantic Center for the Arts' successful fundraising and restoration program, the Cape May Light Station was transferred to that organization through the State of New Jersey. The Coast Guard still maintains access to the active aid to navigation in the historic tower.

insurance) to maintain the catwalk in the future.

The group arranged many local fundraisers to attract attention and assistance for their cause. Once the license to make repairs was issued, they removed all of the existing wood planking on the catwalk. They kept the good boards and cut them into pieces approximately 12 inches in length. Working with local artists and woodcarvers, a silk screened image of the Grand Haven lighthouses and catwalk was placed on each board. Then the wood was carved to make the lighthouses and catwalk stand out and a short history of the catwalk and the group's cause was glued on the back. Each board was sold as "a piece of the Catwalk." This innovative idea raised substantial funds which were later used for repairs and maintenance of the catwalk.

Cape May Lighthouse (New Jersey)

Cape May Lighthouse, a conical brick tower standing 157 feet tall, was completed in 1859. Over the years this lighthouse and others of similar design built along the mid-Atlantic seaboard during the 1850-1870 era, have shown significant structural deterioration. Repairs to the Cape Lookout Lighthouse, North Carolina, (of similar design and built during the same period) to prevent structural collapse of the lantern room cost approximately $300,000 in 1988. Likewise, the Cape May lighthouse needed repair work totaling $200,000-300,000. The U.S. Coast Guard placed this maintenance/repair project on its agenda, and although this work was necessary, it was lower priority than many other repair projects. The high cost of the lighthouse repairs prevented funding; the lighthouse continued to deteriorate, with the only maintenance being performed by servicing personnel who had very limited capabilities.

In 1983, a local citizens group, the Mid-Atlantic Center for the Arts (MAC), expressed an interest in leasing the Cape

May Lighthouse from the U.S. Coast Guard for restoration and public education. After extensive negotiations between the U.S. Coast Guard, the state of New Jersey's Department of Environmental Protection and Energy (NJDEPE), and the MAC group, an agreement was reached. In December 1986 the Coast Guard leased the lighthouse to NJDEPE's Division of Parks and Forestry, which operates an adjoining state park. At the same time, the NJDEPE signed a sublease with the Mid-Atlantic Center for the Arts to restore, maintain, and open the structure to the public.

MAC hired restoration architects to determine the cost to restore the lighthouse. The architects projected that $1,000,000 would be needed over a ten-year period. Over $500,000 has been spent already by the group to allow the public to safely climb to the top of the tower.

The group used many innovative and successful fundraising ideas to pay for completed and planned repairs. In addition to giving tours of the tower and selling lighthouse souvenirs such as T-shirts, pictures, books and magnets, they initiated 'brick owner certificates'. For a nominal $1 a visitor could get a certificate stating that the bearer of such certificate 'owns' one brick of the Cape May Lighthouse in recognition for their contribution to the restoration of this historic landmark. Larger contributors were recognized for 'purchasing' steps ($100), windows ($500), and landings ($1,000). In addition to receiving certificates, contributors of $500 or more were included on a bronze plaque mounted on the first floor of the lighthouse.

As a result of MAC's successful fundraising and restoration plan, the Coast Guard transferred ownership of the Cape May Lighthouse to the Mid-Atlantic Center for the Arts in 1992. U.S. Coast Guard personnel still retain access rights to maintain the active light and associated equipment atop the lighthouse. This undertaking was a win-win situation for both the local community and the U.S. Coast Guard and is an excellent example of how leasing/privatization of lighthouses can succeed under the right management and circumstances.

Funding Sources

The National Historic Preservation Act provides financial support to state historic preservation programs from the *Historic Preservation Fund* managed by the National Park Service. Using these funds allocated to each state, State Historic Preservation Offices provide grants for historic preservation activities throughout each state. At least 10 percent of the HPF allocated to each state must be granted to local governments whose preservation programs have been certified by the State Historic Preservation Officer and the Secretary of Interior. The *certified local government* can use these funds for a variety of historic preservation activities, subject to guidelines established by the National Park Service. A number of states have state-funded grant or loan programs to support historic preservation activities including purchase, rehabilitation, and acquisition of easements on historic properties. Contact your SHPO to receive guidelines on application for federal and state funds and to determine if your project could qualify for certified local government funds.

The *Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)* declares that it is national policy "to develop a National Intermodal Transportation Systems that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner." ISTEA requires coordination in transportation planning between state transportation departments and metropolitan planning organization, and these planning efforts must have a significant public participation component. An important feature of ISTEA is that a minimum of 10 percent of Surface Transpiration Program funds allocated to each state must be used for "transportation enhancement activities." Eligible enhancement activities include acquisition of scenic easements and scenic or historic sites; landscaping; and rehabilitation and operation of historic transportation buildings, structures, or facilities including lighthouses.

The *Housing and Community Development Act of 1974*, as amended, include many provisions including historic preservation. In 1974, the existing law was changed to combine a number of categorical grant programs into a single program under which the Department of Housing and Urban Development (HUD) provides Community Development Block Grants (CDBG) to local government, which have broad discretion in their use. CDBG funds can be used to support historic preservation activities, as well as activities that may damage historic properties. The local government that receives the grants, not HUD, is responsible for compliance with the National Environmental Policy Act and Section 106 of the National Historic Preservation Act. Participation in a local government's housing and community development program is an important activity for many local preservation programs.

Section 170(h) of the *Internal Revenue Code of 1986* permits income and estate tax deductions for charitable contributions of partial interests in historic property. Generally, the donations of qualified real property interest to preserve a historically important land areas or a certified historic structure meets the test of a charitable contribution for conservation purposes. For purposes of the charitable contribution provisions only, a certified historic structure need not be depreciable to qualify, may be a structure other than a building, and may also be a remnant of a building, such as a facade, if that is all that remains, and may include the land area on which it is located.

State arts and humanities councils are also a possible source of funding for particular preservation projects. Private foundations and charitable organizations that fund projects in special fields of interest to your project may also be possible sources of funding. For information on these and other possible funding sources, contact your State Historic Preservation Office and the following sources:

National Endowment for the Humanities
1100 Pennsylvania Avenue, N.W., Suite 318
Washington, D.C. 20506
(202) 606-8310

National Endowment for the Arts
1100 Pennsylvania Avenue, N.W.
Washington, D.C. 20506
(202) 606-5437

The Foundation Center
1001 Connecticut Avenue, N.W.
Washington, D.C. 20036
(800) 424-9836

Use of Volunteers/Community Involvement

One the most important resources in any restoration or interpretation effort is the use of volunteers. Forming partnerships with members of the community where the lighthouse is located can be the most critical element in the success of a lighthouse project. Local businesses may be willing to support restoration projects with donations of supplies or expertise. Citizens may want to show their support not just in monetary ways, but with their time and expertise.

CASE STUDY: Point San Luis Lighthouse Keepers

by Robert S. Vessely, Point San Luis Lighthouse Keepers

The Point San Luis Obispo Light Station at Avila Beach, California, was automated in 1973; subsequently the Coast Guard personnel were moved out of the station and the property was closed. Maintenance and security of the site fell to the personnel of the Port San Luis Harbor District which owns and manages the adjacent harbor. In 1992 the light station and its 30-plus acre reservation were granted to the Harbor District on the condition that the buildings and site be restored in conformance with the *Secretary of the Interior's Standards and Guidelines for Historic Preservation Projects* and be opened to the public.

Almost immediately, the Harbor District and the Land Conservancy of San Luis Obispo County began to study the site and raise funds for its restoration. To handle the dimensions of the task, they set up an organization in 1994—the Point San Luis Lighthouse Keepers—independent of both the Harbor District and the Land Conservancy, for the sole purpose of carrying out the conditions of the agreement. The Lighthouse Keepers is an all-volunteer, nonprofit organization, made up of a wide variety of individuals from throughout the county. Through community outreach and word-of-mouth, the Keepers have developed a solid core of members who are consistently involved and a peripheral group of helpers and patrons.

When the Lighthouse Keepers began to analyze the site, they found a mixed blessing. Many of the original buildings remained, but the weather, vandalism, and theft had taken a serious toll. Fortunately, the fourth-order Fresnel lens had been removed from the tower in 1976 and safely kept in the County Historical Museum. The original tower, which is attached to the head keeper's quarters remains largely intact along with the whistle house, coal house, oil house, catch water basin and cisterns, and one privy. Originally there had been another privy and a 'double dwelling' for the assistant keepers, but they were removed by the Coast Guard. Two new assistant keepers' quarters have been added, one in about 1950 and the other in 1961. The pier that was originally the only means of supply for the station had been damaged and was removed by the Coast Guard.

Fortunately, the roofs of the buildings were in reasonable condition and kept the rain out. Unfortunately, many of the windows and doors had been broken out by vandals. The head keeper's quarters had been stripped of nearly everything, including door and window hardware, light fixtures and even many of the stone mantle pieces. When the Lighthouse Keepers took over, there was literally only one set of door knobs left and a couple of window latches. Since the head keeper's quarters had been partially open to the weather, many of the double-hung window pulleys had been almost completely dissolved by the marine air.

Aside from the restoration issues, the Keepers are faced with a significant access obstacle. The road to the light station is a narrow, winding, one-lane road precariously perched on the bluff above the bay. In addition, it crosses land owned by Pacific Gas and Electric Company (PG&E), which operates the Diablo Canyon nuclear power plant just four miles up the coast from the light station. Originally the road was built

Point San Luis Lighthouse Keepers photo

Point San Luis Lighthouse Keepers photo

Figures 9 and 10. The Point San Luis Keepers devote one Saturday a month to preserving the San Luis Obispo Light Station, Avila Beach, California.

on an easement granted by the previous property owner, but whether or not the easement is transferable is not clear. PG&E will allow the Lighthouse Keepers access for restoration work, but will not allow access by the general public. Clearly, the legal and physical status of the road will have to be improved before the light station can be opened to the public. The Lighthouse Keepers and the Harbor District have explored the idea of replacing the light station pier, but the complications and costs of that are just as daunting.

The Lighthouse Keepers have organized on a number of fronts. Committees have been set up to study the buildings and make recommendations about restoration, to collect oral histories from people who lived at or had contact with the light station when it was in operation, to study the access issues, and to work on fundraising. Monthly work days have been established. One Saturday each month the group cleans, trims trees, replaces windows, scrapes and applies paint, inventories doors or hardware, and documents the buildings and site. These workdays have proven to be an important part of the 'glue' that holds the Lighthouse Keepers together. Everyone enjoys the work days—skilled professionals and others as well. It's a chance to have a 'hands-on' part in the restoration.

Relocating Lighthouses

Recently there has been much publicity over the movement of lighthouses in an effort to save them from impending dangers such as erosion. When the Lighthouse Establishment approved the first Sharps Island Lighthouse, built in 1837 in Chesapeake Bay, the plans called for a small wooden keeper's house surmounted with a lantern and designed with 'wheels' so it could be easily moved in the event that erosion threatened the structure. The lighthouse was so moved in 1848, presumably on these wheels.

Likewise the U.S. Lighthouse Board well understood the dangers of erosion; several lighthouses were specifically designed to be moveable. In areas with shifting and eroding beaches, cast-iron plate towers were designed so they could be disassembled and re-erected as needed. This was relatively easy to accomplish as the prefabricated, curved, cast-iron panels were bolted together. Cape Canaveral Lighthouse (1868), Florida, and Hunting Island Lighthouse (1875), South Carolina, are examples of this design; both have been successfully moved.

The National Park Service has conducted studies which conclude the safest method to preserve Cape Hatteras Lighthouse, which is presently being threatened by erosion, is to move it back from the beach front. Ironically, some citizens argue that such a move will destroy the integrity of the lighthouse setting. Actually, when the Cape Hatteras Lighthouse was built in 1870, it was located approximately one-half-mile inland to protect it from beach erosion. But erosion of the beach has encroached to the point where it now endangers the structure. The movement inland of the lighthouse and its other station structures would in reality present a more appropriately true setting of the lighthouse as it appeared when it was first completed.

Should a lighthouse be moved? The best answer is no—unless the structure is threatened by destruction. While any historic structure is best located in its original location, it is better to have a historic structure in a non-original location than to have no historic structure at all. If a move is necessary to save the structure, every effort should be made to maintain as much of the original station integrity as possible. The lighthouse tower should normally have the same orientation to the water as it had before the move. Other station structures should be similarly moved to demonstrate the same relationship of one structure to the other. Landscaping can also be used to help restore the original setting of the station. Before any move of any historic structure is undertaken, contact your SHPO. Any historic structure listed in the National Register of Historic Places may lose such designation once moved. If a move is absolutely necessary and approved by the SHPO, make sure the move is conducted by a reliable moving company with proven success.

ICC photo

Figure 11. Block Island Southeast Light Station before the move.

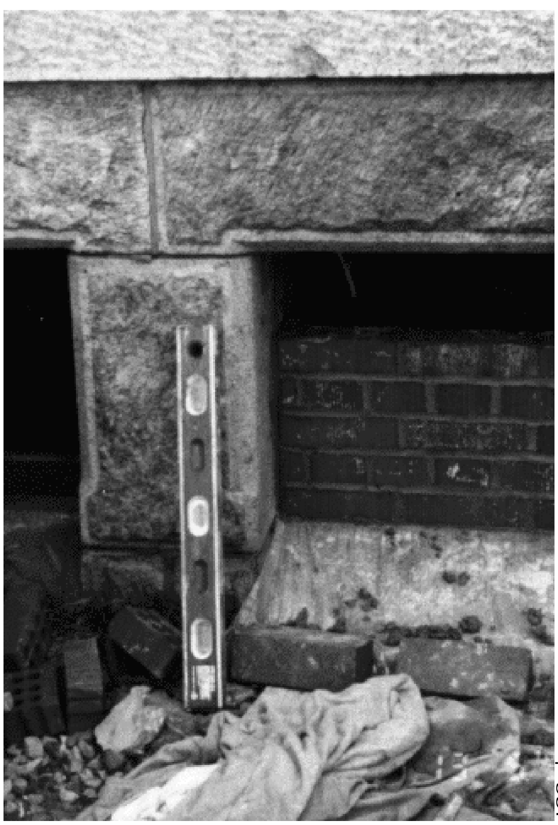
CASE STUDY: Relocation of the Block Island Southeast Lighthouse

by Mike E. Prible, International Chimney Corporation

When originally constructed in 1873, Block Island's Southeast Lighthouse rested safely atop Mohegan Bluff on the Southeast tip of Block Island, Rhode Island, approximately 150 feet above sea level. By 1993, 120 years of erosion had whittled the 300 feet of land between the lighthouse and the edge of Mohegan Bluffs down to a mere 55 feet, putting the lighthouse in danger of crashing into the sea.

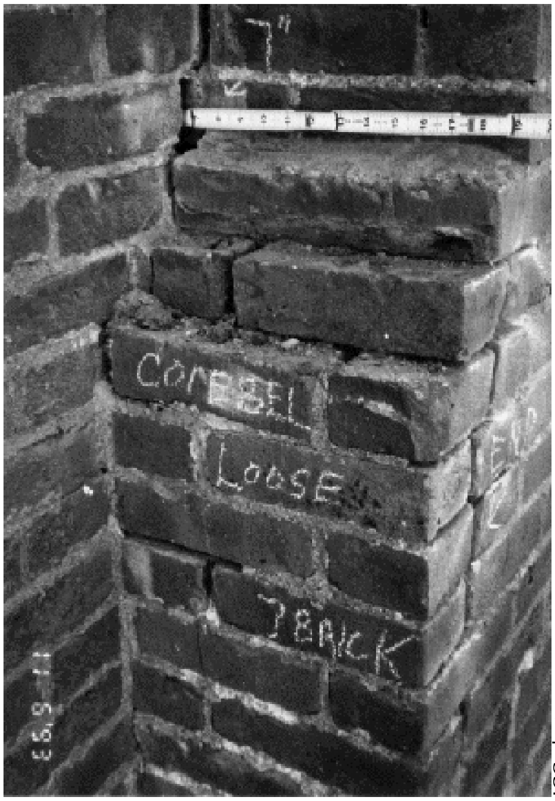
Thanks to local preservation efforts, money was raised to save the historic lighthouse. In February 1993, International Chimney Corporation (ICC) of Buffalo, New York, was awarded a $1.9 million dollar contract by the U.S. Army Corps of Engineers to move the lighthouse to safety, back away from the edge of Mohegan Bluffs. The move was paid for with money raised by local sources and funding from the State of Rhode Island and the Federal Government. ICC's plan called for the entire lighthouse, complete with attached masonry building and upper portion of the original foundation, to be moved intact.

An ingenious and complex system was devised to move the lighthouse over its 360-foot journey. Pete Friesen, a noted consultant in the house-moving field worked with ICC to design the move. In simplified terms, the entire weight of the lighthouse (estimated at a total of 4,000,000 pounds) was to be transferred from its masonry foundation to a grid of



ICC photo

Figure 12. In preparation for the move, the cellar windows openings are temporarily bricked in to stabilize the masonry above the lift point.



ICC photo

Figure 13. A complete structural survey of the building was performed and documented in order to perform the structural repairs necessary to move the building intact. All loose or eroded mortar joints were cut out and carefully pointed with a new mortar mix designed to closely resemble the original. All chimneys were braced and cabling installed around the perimeter to catch problem areas.

ICC photo

Figure 14. The concrete floor of the light tower was removed and earth excavated by hand in order to perform stabilization from the interior of the structure.

crisscrossing steel beams and then pushed along tracks to its new home. The tracks were made of steel beams with case-hardened strike plates and laid on oak cribbing along a zig-zag path between the old lighthouse location and the new. In all, approximately 800,000 pounds of steel was used in the beam grid and track system.

In April 1993, after a detailed engineering analysis and planning, the design was complete. Preparations at the site began. The 237,000-candle-power Fresnel lens, handcrafted in France (seen from as far away as 22 miles), was packed with sound- and vibration-dampening insulation to protect it during the move. Fire escapes and porches were removed, with porch roofs left in place. All mechanical equipment was removed from the basement. Six feet of earth was excavated from around the entire lighthouse and a path between the original foundation and the new foundation was excavated—a total of approximately 5,000 cubic yards of earth in all. Cellar windows were bricked in, the beam grid system installed, a new 18-inch-thick reinforced concrete slab foundation constructed, and other preparations made. Approximately 245 yards of concrete, 75 yards under the tower and 170 yards under the building, and 72,000 pounds of steel reinforcing were used in the new slab foundation. Other reinforcing included wooden bracing in window openings and around chimneys, 3/4-inch-diameter steel cabling around the entire structure, temporary wooden bracing supporting porch roofs, and bricked-in window openings.

Transfer of the lighthouse to the beam grid was accomplished by cutting holes through the original foundation, below grade level; then beams were inserted through the holes, in one side of the building and out the other. Multiple levels of beams were required. The lighthouse rested on an upper level of cross beams that were perpendicularly seated on four duplex main beams, which would house the hydraulic jacks. Thirty-eight hydraulic lifting/levelling jacks (capable of lifting 60 tons each) were installed to lift the lighthouse and to keep it level during the move. Thirty-eight 75-ton Hilman roller dollies were installed under the jacks. Once all the beams were in place, remaining portions of the foundation (the area between holes cut in the foundation) were removed. ICC worked in unison with Expert House Movers, a subcontractor experienced in moving large structures.

Following the transfer of the lighthouse load from its foundation to the beam grid, all 38 hydraulic lifting jacks were activated in unison and the entire structure was raised vertically approximately 2 feet from its original elevation. The structure was then cribbed on oak timbers, tracks positioned below and parallel to the main beams, and the hydraulics for the jacks rerouted to three separate zones to allow for compensation on uneven surfaces during travel, i.e., no stress would be placed on the structure if a bump or soft spot was encountered, because the structure would roll like a ship rather than bend. By August 11, 1993, preparations were complete. The lighthouse was ready for the move.

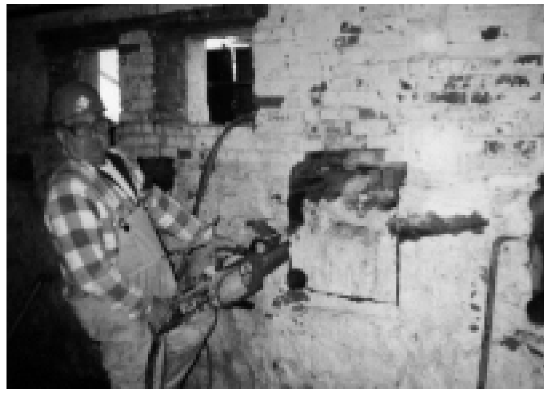

ICC photo

Figure 15. A hydraulic chain saw with industrial diamond teeth is being used to cut openings below the grade line for insertion of the steel beams.

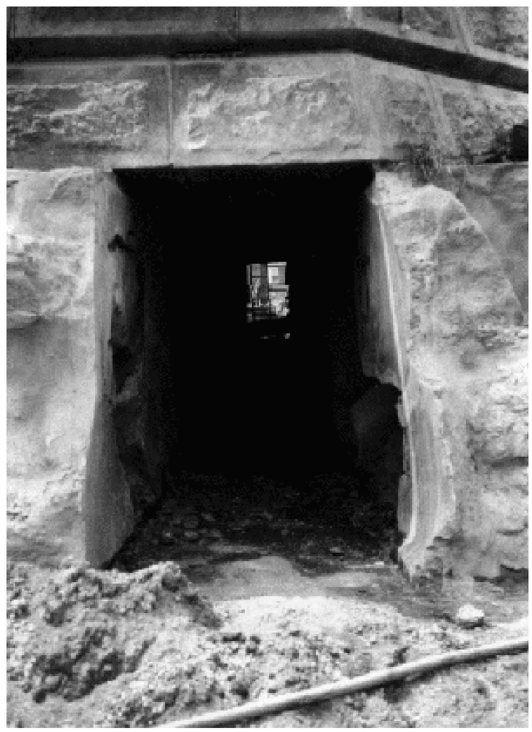

ICC photo

Figure 16. Close-up of the opening for the beam cut by the wire saw measuring 5 feet high by 3 feet, 6 inches wide. The depth of the cuts ranged from 18 inches to 16 feet for multiple wall cuts.


ICC photo

Figure 17. A foundation slab is being poured using 36 tons of rebar and 245 yards of concrete. This 18-inch-thick slab was designed to handle the dynamic load of the building travelling across the slab to its final position.

Figure 18. Large cross steel beams are inserted into the cut opening to form part of the grid that will carry the building.

Figure 19. Once the initial lift was performed, the remaining foundation between the beams was removed.

Figure 20. Four hydraulic rams set into the track steel pushed against the main steel to set the lighthouse in motion.

The move was accomplished by pushing the lighthouse along its newly installed track system in 5-foot increments with four hydraulic pushing rams (capable of pushing 30 tons each). After the lighthouse was pushed approximately 5 feet, all four pushing rams had to be retracted for the next 5-foot move. The lighthouse did not travel in a straight line from its original location to its new home. If this were done, loads on the network of beams under the lighthouse would have become too uneven. Instead, the move was accomplished in three separate stages (legs). Time was required between legs of the move for changes in the track system in preparation for the 90-degree change in direction the lighthouse was about to take.

On August 24, 1993, Block Island Southeast Lighthouse reached its new home. It sat positioned with approximately 5 feet between the top of its new reinforced concrete slab foundation and the underside of remaining portions of its original masonry foundation. Solid brick was laid to fill the 5-foot gap (approximately 80,000 brick were required). Beams used to support the lighthouse during its journey were removed after brick was laid between the beams to carry the load. Wooden bracing and other temporary measures were removed; porches were installed; grading, landscaping, and final cleanup tasks completed. Once again, the Block Island Southeast Lighthouse rests a safe distance from the edge of Mohegan Bluffs, still facing in its original direction.

Subsequent restoration work performed in 1994 focused on the stabilization of the lower gallery deck and disassembly, repair, and isolation of all lantern elements. This

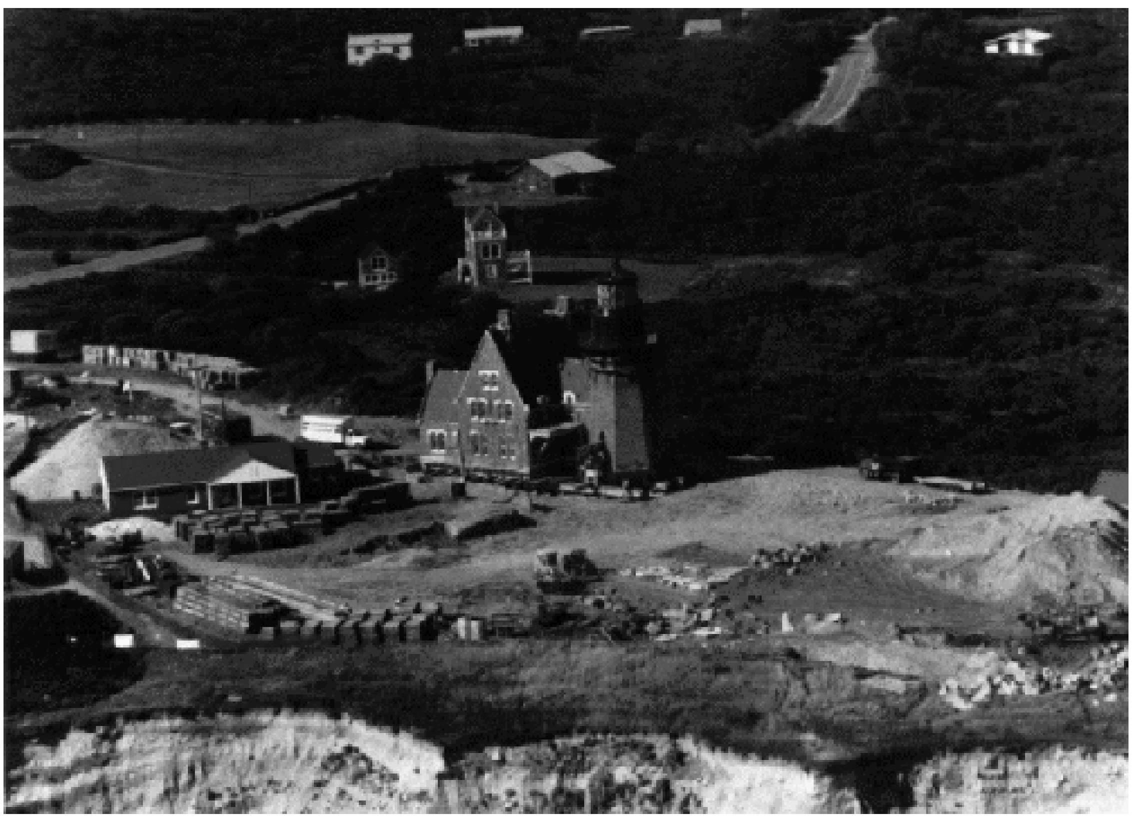
ICC photo

Figure 21. After the first leg of the journey was completed, the track steel was repositioned for a 90° turn.

ICC photo

Figure 22. Construction of a new foundation around the support beams.

included removal of the existing lens and pedestal, the design and installation (by the Coast Guard) of a different fixed lens, and installation of a new lens support platform.



ICC photo

Figure 23. On August 23, 1993, the Block Island Southeast Light Station reached its new home.

Safety Management Issues

Lighthouse towers were not designed for access by the general public and were built before modern building code regulations. Therefore, providing safe access to light towers for the general public is challenging. The most serious concerns include: tripping on stairs; falling, either deliberately or unintentionally, from the tower; throwing of objects from tower; visitor behavior; emergency evacuation; and fire safety. Because of these concerns, some lighthouse sites restrict public access to the tower altogether.

Tripping: Proper lighting and handrails are the two most critical methods for reducing tripping on stairs. Most stairs in lighthouse towers consist of a spiraling series of pie-shaped treads. The narrow part of the tread toward the center of the tower is the most dangerous because there is usually no hand rail and the tread to riser ratio of the stair makes a misstep more likely to lead to a trip, possibly resulting in a fall. Precautions used at some lighthouses include the placement of a second inner handrail about two-thirds of the way across the tread. This keeps visitors from using the narrow portion of the tread and provides a second handrail. In larger lighthouses where the tread is wide enough, visitors going up can use the outer handrail along the inner wall of the tower and visitors going down can use the inner handrail. In smaller towers where it is difficult for visitors to share the stairs going both up and down, it may be necessary to limit access to guided tours and/or alternating one-way sections along the stairs; similar to traffic lights on a one-lane bridge.

Stairwells are often not well lit so that sections between landings where windows are usually located are dark. On cloudy days these sections become even less well lit. Artificial lighting can also create

Figure 24. Visitors are prohibited from the Barnegat Lighthouse's lantern room; however, they can view it from the watch room through plexiglas sheets. While these protective sheets prevent access to the lantern room, they do collect dust and need periodic cleaning. In other lighthouses, a person is stationed in the watch room to prohibit access to the lantern room as well as control visitor behavior.

problems if not well designed. For example, many treads in light towers are cast-iron treads with perforations cast into them to make them lightweight. Light directed from below may shine through the treads and/or around them, making the tread surface appear less visible to those descending the stair. Strong light directed into the eyes of climbers can also affect their ability to see the stair tread surfaces properly. At one lighthouse tower (Cape May), strip lighting, similar to that seen in movie theater isles, was placed under the nose of each tread illuminating the surface of the tread below. Installations of such systems can be made reversible so they do not permanently harm the historic fabric of the structure.

Falling: For those lighthouses where visitors are allowed to access the gallery decks around the watch room and/or lantern, special precautions must be taken to keep visitors from accidentally falling or from attempting suicide. Some visitors who are not in good health, while climbing the stairs and/or upon reaching the gallery deck may experience dizziness, cardiac or respiratory distress, disorientation, fear of heights, unsteadiness of legs, etc. High temperatures in the upper portion of a tower may also be a health hazard. All of these symptoms may contribute to accidental falling. The most effective method used by many lighthouse groups is to build a metal cage that fits around the gallery deck. The maximum space between pickets should be no more than four inches (BOCA, Building Officials & Code Administrators, International). The pickets need to completely extend to a structural element above or bend back to the tower/lantern wall so no one, even if deliberately climbing, could get over the top. One lighthouse suicide in 1995 was accomplished by climbing between overhead cage pickets with 9-inch spacing. Cages can be designed so they are attached reversibly to light towers without doing any permanent damage to the historic fabric of the structure.

NMI photo

Figure 25. To protect visitors from falling or jumping from a lighthouse tower, a safety railing system or 'cage' is often built around the gallery decks. The cage at Barnegat Lighthouse was designed so that it has minimal impact on the historic structure and can be removed with little, if any, damage to the original fabric. Note that the cage is also enclosed to prevent climbing over the top.

NMI photo

Figure 26. Note how the cage is clamped to the gallery deck, minimizing any impact on the structure's original fabric.

Throwing Objects: The throwing of objects from any height can cause serious harm, even death, to visitors below. The use of screens, such as rat-wire, will limit such practices but can also detract from the visitor experience. Most lighthouses have adopted the practice of prohibiting the throwing of objects from the tower as part of the rules for being admitted to the tower. Docents must be present at the top of the tower to remind visitors, especially children, of such rules.

Visitor Behavior: While most visitors do not run up or down stairs, push or pass others on the stairs, climb rails, throw objects, or "horse around," there will always be that small faction who do. Children often run ahead of their parents and essentially become unchaperoned; large school groups also can be problematical. Others just do not realize the hazards of a lighthouse tower. Many lighthouse groups have devised "rules" for visitors which are posted at the base of the tower and which visitors are expected to follow. These same rules are often provided in onsite brochures. Caution can also be indicated on signage, warning those in poor physical condition of potential hazards to their health. It is helpful to indicate the total height of the climb and number of stairs to the top. Some larger lighthouses which have stair landings provide a cross-section of the tower plan showing visitors where they are in relation to the top or bottom of the tower. Many lighthouses also have someone at the bottom and someone at top to help control visitors.

Weather conditions: Adverse weather conditions such as high velocity winds, rain, and lightning may force lighthouse sites to close temporarily for safety reasons.

Emergency Evacuation for Injury & Accidents: The most probable injury/ emergency is an accident from tripping, falling, or heart attack. Most lighthouse groups have a person on station at the bottom and one at the top of the tower. For tall towers this is essential. These individuals must have communication between themselves and outside help in the form of a telephone or walkie talkie. They should be trained in first aid, CPR, and have a clear understanding of when to and when not to move an injured individual. They should also have written guidelines on proper procedures for notifying the police and/or ambulance. It is highly recommended to keep a well stocked first-aid kit onsite at all times.

Fire: Another concern is fire. Smoke in the tower can make emergency evacuation from a tower very difficult. This is especially true for a light tower attached to a keepers quarters or other structures where a fire might begin and affect evacuation from the tower itself. Staff, whether paid or volunteer, must have training in fire evacuation procedures, which in some cases may require keeping visitors on the gallery deck instead of descending into the smoke. Smoke detectors are difficult to position in a lighthouse tower as smoke is not trapped until it reaches the watch room and/or lantern. Many types of smoke detectors are not rated for use in unheated buildings or for below-freezing temperatures; towers in areas with subfreezing environments will require another solution. Lighthouse towers are not treated as a separate building type in code books. One lighthouse tower was successfully evaluated as an aviation traffic control tower as far as meeting fire code concerns. Lighthouse organizations need to work closely with their local fire marshal and code officials. Preparation of fire safety objectives is strongly recommended (see following text, "Fire Prevention and Protection Objectives").

Americans with Disabilities Act (ADA): Providing accessibility for people with disabilities in historic lighthouses and associated structures is an important and challenging task. To balance accessibility and historic preservation mandates, owners of historic properties should take care to provide the greatest level of accessibility without threatening or destroying features and materials that convey a property's significance. New construction and alterations to historic properties, including restoration and rehabilitation, must meet specific accessibility requirements (in general, maintenance, such as reroofing and painting, do not trigger specific compliance requirements). While ADA regulations mandate that accessibility for the disabled be given priority, if it is not possible to make a historic building physically accessible without threatening or destroying its significance, which is the case with most lighthouses, alternative methods of access must be used. This includes management of interpretive programs and media, such as audio/visual materials and other interpretive devices which show inaccessible areas of the historic property, and/or displays and written material located where it can be used by an impaired, challenged, or disabled person. These alternatives are only possible for "qualified historic properties" such as those listed or determined eligible for listing on the National Register of Historic Places, and those designated under State or local law, and only after consultation and approval from your State Historic Preservation Officer (SHPO) (see Part VI., **Resources** for SHPO list). A useful free brochure on this issue, "Preserving the Past and Making it Accessible for People with Disabilities," is available from the National Park Service's Heritage Preservation Services (see Part VI., **Resources**).

Fire Prevention and Protection Objectives

Despite the fact that most lighthouses are constructed of noncombustible materials,[1] fire can still be a threat to historic lighthouses. The impacts of a fire are devastating and will often cause serious irreversible damage and loss of historic fabric, not to mention injury or even death to its occupants. Fire prevention and protection work together to create a fire safety plan. The working assumption must be that there will be a fire despite the best prevention efforts. Fire safety plans for the control of a fire, or for understanding the consequences of lack of fire control, must be developed and must be realistic. Prevention planning is the most important element of protecting historic lighthouses and their admiring public from fire.

A systematic approach to fire prevention should seek to satisfy the following three general fire safety objectives: prevent fire ignition; control the effects of fire should one start; and protect the building occupants and contents from the effects of a fire. A fire safety plan would also help in identifying those architectural features of the lighthouse which are significant; part of the plan would be to identify ways to limit damage to the structure caused by fire, smoke, and firefighting efforts.

In historic lighthouses the most important of these three goals is to prevent fire ignition. Fire prevention management is essentially the control of possible ignition sources within the lighthouse. Three conditions contribute to ignition: inadequately controlled ignition sources, hazardous arrangements of fuel, and circumstances or behaviors that bring the two together.

[1] Twelve percent of all lighthouses are constructed of wood according to the National Park Service's *1994 Inventory of Historic Light Stations*.

There is seldom a high degree of control over these conditions. Consequently, lighthouse managers must be alert to their possible presence in a project and be prepared to control or compensate for them.

Identify possible ignition sources such as fuel and seek to control or eliminate them. The three most common sources of ignition are: open flame (especially related to careless use of smoking materials), electrical energy (arc), and mechanical energy (friction).

Suggestions for minimizing the threat of ignition are:

- To minimize fires caused by vandalism the interior should be kept clean and free from storage of maintenance and operational equipment and supplies. This includes items such as fuel containers, old batteries, lawn mowers, bulk paper, or rags, etc., as well as combustible materials. Grounds should be kept in a similar manner. Security is another high priority and all openings should be secured to prohibit unauthorized entry.
- To minimize the threat of an electrical fire, any existing electrical service should be inspected by a licensed electrician. Any deficiencies should be corrected or the service should be disconnected if there is no need for power. This is especially critical during times of stabilization or mothballing when the structure is likely to be unoccupied for long periods of time.

Tragically, another frequent cause of fire is construction activities. Work taking place during the protection and stabilization phase has often created dangerous situations sometimes leading to disaster. Careful planning and oversight of construction activities should include the development and use of a strict fire safety plan. Storage of combustible or volatile construction or housekeeping materials such as paints, solvents, cleaning fluids and rags, packing materials, or fuels in the lighthouse must be prohibited.

- Open flames should not be allowed in or near the lighthouse. If the structure has a fireplace or stove pipe connection, chimneys, flues, or stoves, they should be inspected regularly and fires permitted only under strict guidance with properly rated fire extinguishers nearby. The use of fire in a historic setting for interpretive reasons must be carefully considered. Smoking should be prohibited in all locations.
- Hazardous areas, such as a generator room, should be compartmentalized and separated through the use of fire-rated partitions if they are located in the historic lighthouse. Removing this type of use from the historic structure is another alternative.

NFPA[2] 241 "Safeguarding Construction, Alteration and Demolition Operations"; NFPA 911 "Protection of Museums and Museum Collections"; and NFPA 914 "Recommended Practice for Fire Protection on Historic Structures" offer valuable guidance in developing fire prevention and protection strategies.

Suggestions for controlling the effects of fire after one has started:

- Fire extinguishers should be located at various positions throughout the lighthouse for prompt use in the event of a localized emergency. Local authorities should be brought in for a tour of the structure and grounds so they may assist in planning the number, type, and location of fire extinguishers or other firefighting equipment. Fire extinguishers require annual inspection and maintenance. Some types should not be subject to below-freezing temperatures.
- In populated areas a Neighborhood Watch program can be organized in cooperative effort with local police and fire department authorities. An intrusion alarm system connected to a central station alarm will alert managers to vandalism events.
- There are two ways to detect a structure fire: human observation and fire-detection systems. Unfortunately, most historic lighthouses are no longer occupied on a full-time basis. Therefore,

[2] National Fire Protection Association (NFPA), Quincy, Massachusetts, 617/ 770-4543

photoelectric smoke detectors and mechanical heat detectors should be used to supplement the human detector capability when it makes sense. Photoelectric- or ionization-type smoke detectors are not rated for use in below-freezing environments. Consult with local authorities or professionals for placement, number, and types of detectors.

A combination of heat and smoke detectors connected to a central station alarm is an effective way to detect fires when a signal can be relayed to authorities who can respond in a timely manner. Heat and smoke detectors must be used to create a system designed for each individual structure as each building has its own unique fire behavior. The use of these systems is more problematic with lighthouses located in remote areas, although an emergency response plan should still be developed.

- An evacuation plan should also be developed with the local authorities. The performance of the tower itself as a natural chimney must be carefully considered, especially if the attached vestibule house or dwelling house construction is combustible. Since most lighthouse towers have only one means of egress, and that may be through a combustible structure, evacuation must be carefully planned. This plan should be posted at entry points and available onsite for education of all docents.
- An emergency or disaster plan should be drawn up by responsible parties. Local authorities should have input. Meeting with the local fire department or volunteer fire company is a first step. Orientation to the structure will familiarize the authorities with the nature of the structure and will allow for discussion of local options for dealing with fire prevention, detection, firefighting strategies, and other emergencies. This plan should also identify the important architectural features of the structure which warrant special attention and protection during firefighting operations.

An important part of managing a fire is support for firefighters. Develop a firefighting plan with the local authorities as part of the emergency or disaster plan. There may be specific character-defining features of the lighthouse that are more important to protect than others. Historic lighthouse managers should talk about these concerns with firefighting officials. Work with them to develop strategies for placement of water streams and identification of locations where smoke vents will be opened through the structure. Loss of historic fabric is inevitable, but identifying what is important will help fire fighting officials plan their strategy to minimize damage to the historic lighthouse.

Protecting the building occupants and contents from the effects of a fire is an important consideration, especially at sites where the lighthouse complex is open to the public and may include museum facilities housing precious, irreplaceable artifacts. In these instances careful attention must be given by lighthouse managers to the primary protection of life safety and secondarily to the museum artifacts. Working with registered architects or fire department authorities to develop a realistic and manageable fire safety program should be a top priority for the historic lighthouse management community.

See also the following references: NFPA 1 “Fire Prevention Code”; NFPA 10 “Standards for Portable Fire Extinguishers”; NFPA 17 “Standard for Dry Chemical Extinguishing Systems”; NFPA 70 “National Electrical Code”; NFPA 78 “Lightning Protection Code.”

Historic Lighthouse Preservation: RESOURCES

Figure 1. Front elevation drawing plan (1886) for Horn Island Light, Mississippi.

Glossary

Preservation Terms

Advisory Council on Historic Preservation (ACHP)—The National Historic Preservation Act created the Advisory Council on Historic Preservation, an independent federal agency with statutory authority to review and comment on federal actions affecting properties listed in or eligible for the National Register of Historic Places, to advise the President and the Congress on historic preservation matters, and to recommend measures to coordinate activities of federal, state, and local agencies. Its members include Cabinet-level representatives from Federal agencies and presidential appointees from outside the Federal government.

Archaeological and Historic Preservation Act—Archaeological and Historic Preservation Act (AHPA) of 1974 (P.L. 93-291m 88 Stat. 174; 16 U.S.C. §§ 469-469c) directs Federal agencies to report to the Secretary of the Interior when their actions may damage archeological sites, and to conduct or assist in the recovery of data from such sites. AHPA authorizes transfer of up to 1% of project funds to the Department of the Interior to help cover costs of such recovery.

Archeological Resources—As defined by Archeological Resources Protection Act, an archeological resource "is any material remains of past human life or activities which are of archeological interest, as determined under uniform regulations promulgated to this Act... Non-fossilized and fossilized paleontological specimens... shall not be considered archeological resources...No item shall be treated as an archeological resource...unless such item is at least 100 years of age." Examples include but are not limited to: pottery, basketry, bottles, weapons, tools, pit houses, rock paintings, rock carvings, graves, and human skeletal materials. Such resources are capable of revealing scientific or humanistic information through archeological research.

Condition Assessment Report—A written document which is the result of the inspection, documentation, and analysis of the physical condition of the features of an asset on which work is performed or creates an identifiable workload. The Condition Assessment Report will typically include recommendations for corrective treatment of known maintenance deficiencies as measured against the applicable maintenance or condition standards. An asset is the real property which is managed as a distinct identifiable entity. It may be a physical structure (lighthouse, keepers quarters, lens) or a grouping of structures, land features, or other tangible property which has a specific service or function. A feature is a distinct element or separately identifiable part of the structure. Examples of lighthouse specific features are tower, lantern, interior stair, gallery deck, gallery brackets, lantern deck, lantern glass, ventilation devices, roof structure, roof covering, ventilation ball, interior doors, hardware, window frame, lens pedestal, lens, etc. The condition assessment report provides the basis for long-range maintenance planning as well as annual work plans and budgets. There are varying degrees of inspection and assessment and these must be tuned to the improvement requirements for the lighthouse.

Major Assessment—A specialized type of Condition Assessment in which the focus is on identifying and documenting long-range maintenance, repair, restoration, major modification, and improvement requirements for assets (historic structures) and their features. Major Assessments are usually conducted by experienced professionals on an as-needed basis.

Scheduled Assessment—Condition Assessment conducted at the local level, typically by staff or well trained volunteers, with the intent to develop the annual maintenance work requirements for the structure (lighthouse).

Cultural Resource—An aspect of a cultural system that is valued by or significantly representative of a culture or that contains significant information about a culture. Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register [of Historic Places] including artifacts, records, and material remains related to such property or resource.

Cultural Resource Management—The range of activities aimed at understanding, preserving, and providing for the enjoyment of cultural resources. It includes research related to cultural resources, planning for actions affecting them, and stewardship of them in the context to overall agency operations. It also includes support for the appreciation and perpetuation of related cultural practices, as appropriate.

Documentation—Recording the condition of a structure or object before, during, and after reconstruction, rehabilitation, restoration, stabilization, etc. using visual (photography, drawings, etc.,) and written (notes, transcripts, etc.) means.

Executive Order No. 11593, *Protection and Enhancement of the Cultural Environment*—Executive Order No. 11593, May 13, 1971, Protection and Enhancement of the Cultural Environment (36 Fed. Reg. 8921, reprinted in 16 U.S.C.§ 470 note) was issued by President Nixon. It elaborated on Federal agency responsibilities under NHPA and NEPA and included direction for agencies to identify historic properties under their jurisdiction or control, extended Section 106 review to effects on "eligible" properties, and gave the Advisory Council on Historic Preservation independent agency status. Many of these responsibilities were folded into NHPA by amendment in 1980.

Federal Preservation Officers—The National Historic Preservation Act mandates that each federal agency must have a designated Federal Preservation Officer (FPO). Both the Coast Guard and the Department of Transportation have designated FPOs as does the Department of the Navy. The FPO is the official designated by the head of each Federal agency responsible for coordinating that agency's activities under the NHPA of 1966, as amended, and Executive Order 11593 including nominating properties under that agency's ownership or control to the National Register.

Federal Property and Administrative Services Act—The Federal Property and Administrative Services Act of 1949 as amended in 1972 (40 U.S.C.§ 484(k)(3)) authorizes the General Services Administration to convey approved surplus Federal property to any State agency or municipality free of charge, provided that the property is used as a historic monument for the benefit of the public. The act is also applicable to revenue-producing properties if the income in excess of rehabilitation or maintenance cost is used for public historic preservation, park, or recreation purposes and the proposed income-producing use of the structure is compatible with historic monument purposes, as approved by the Secretary of the Interior. The act includes provisions under which the property would revert to the Federal Government should it be used for purposes incompatible with the objective of preserving historic monuments.

Folklore/Folklife—The traditions, beliefs, and customs, etc. of people which are preserved in song, stories, crafts, oral histories, and other lifeway forms.

HABS/HAER—Historic American Buildings Survey/ Historic American Engineering Record—The Historic American Buildings Survey (HABS) is the oldest Federal preservation institution. Created in 1933, as a Works Progress Administration (WPA) program, to document the historic architecture of the United States through existing condition measured drawings, large-format photography, and written historical reports. This documentation has for generations provided baseline records for restoration or renovation, and is a permanent archival and insurance record. The Historic American Engineering Record (HAER) was created in 1969 and charged with documenting the nation's rapidly disappearing early engineering, industrial, and transportation structures. HAER employs many of the same documenting techniques as HABS, but has also developed new graphical methods for charting industrial processes in factories, mines and mills. Since 1933 HABS and HAER have employed over 3,000 architects, engineers, historians, and photographers in the documentation of over 32,000 structures.

Historic or Pre-Historic Real Property—Any archeological or architectural district, site, building, ship, aircraft, structure, or object, as well as monuments, designated landscapes, works of engineering, or other property that may meet the criteria for inclusion in the National Register of Historic Places or an equivalent register maintained by a State or local government or agency.

Historic Preservation—Includes identification, evaluation, recordation, documentation, curation, acquisition, protection, management, rehabilitation, restoration, stabilization, maintenance, research, interpretation, conservation, and education and training regarding the foregoing activities or any combination of the foregoing activities.

Historic Records—Any historical, oral-historical, ethnographic, architectural, or other document that may provide a record of the past, whether associated with real property or not, as determined through professional evaluation of the information content and significance of the information.

Historic Site—A site of a significant event, prehistoric or historic occupation or activity, or structure or landscape whether extant or vanished, where the site itself possesses historical, cultural, or archeological value apart from the value of any existing structure or landscape.

Historic Sites Act—The Historic Sites Act (HSA) of 1935 (P.L. 74-292, 49 Stat. 666; 16 U.S.C.§§ 461-467) established as national policy "to preserve for public use historic sites, buildings and objects of national significance for the inspiration and benefit of the people of the United States." The Act authorizes and directs the Secretary of the Interior to make a "survey of historic and archeological sites, buildings, and objects for the purpose of determining which possess exceptional value as commemorating or illustrating the history of the United States." This program has become known as the National Historic Landmark Program and properties so designated are referred to as National Historic Landmarks (NHLs). NHLs are usually designated as part of 'theme studies' such as War in the Pacific, Man in Space, and a current theme study on American Lighthouses. NHLs are automatically listed on the National Register. Establishes a maximum fine of $500 for violation of the Act.

Historic Structures—Historically significant constructed works usually immovable by nature or design, consciously created to serve some human activity. Examples are historic buildings of various kinds, monuments, dams, roads, railroad tracks, canals, millraces, bridges, tunnels, locomotives, nautical vessels, stockades, forts and associated earthworks, Indian mounds, ruins, fences, and outdoor sculpture. In the National Register program, "structure" is limited to functional constructions other than buildings.

Historic Structure Report (HSR)—The National Park Service's historic structure report (HSR) is the primary guide to treatment and use of a historic structure and may also be used in managing a prehistoric structure. Groups of similar structures or ensembles of small, simple structures may be addressed in a single report.

An HSR includes the following:

> *Management Summary*. This is a concise account of research done to produce the HSR, major research findings, major issues identified in the task directive, and recommendations for treatment and use. Administrative data on the structure and related studies are included.
>
> *Part 1, Developmental History*, is a scholarly report documenting the evolution of a historic structure, its current condition, and the causes of its deterioration. It is based on documentary research and physical examination. The scope of documentary research may extend beyond the physical development of the structure if needed to clarify the significance of the resource or to refine contextual associations; however, major historical investigation of contextual themes or background information should be conducted as part of a historic resource study.
>
> *Part 2, Treatment and Use*, presents and evaluates alternative uses and treatments for a historic structure. Emphasis is on preserving extant historic material and resolving conflicts that might result from a structure's "ultimate treatment." Part 2 concludes by recommending a treatment and use responding to objectives identified by park management. In most cases, design work does not go beyond schematics.
>
> *Part 3, Record of Treatment*, is a compilation of information documenting actual treatment. It includes accounting data, photographs, sketches, and narratives outlining the course of work, conditions encountered, and materials used.

Historical Significance—The meaning or value ascribed to a structure, landscape, object, or site based on the National Register criteria for evaluation. It normally stems from a combination of association and integrity.

Intermodal Surface Transportation Efficiency Act (ISTEA)—Public Law 102-240, enacted in 1991 is a 6-year reauthorization of federally funded transportation programs. Ten percent of the funding has been set aside for transportation enhancements and may be used on different activities, six of which are preservation related. Lighthouses are transportation related and may qualify for preservation funding through creative and cooperative programing.

Major Modification—Work performed on an asset (historic structure) that is beyond the scope of day-to-day corrective, preventative, or routine maintenance. Major modifications typically involve capital improvements; large scale restorations, rehabilitations, or repairs; demolitions; or conversions of an asset. Usually, major modifications are managed as distinct projects, not maintenance.

Mothballing—The temporary closing of a structure such as a building or ship to protect it from the weather, reduce the rate of deterioration of materials and systems, and secure it from vandalism. In Navy facility management, this term is synonymous with layaway.

National Environmental Policy Act—The National Environmental Policy Act of 1969 (NEPA)(P.L. 91-190, 31 Stat. 852; 42 U.S.C.§§ 4321-4370) created a new context in which the management of all kinds of cultural resources could be addressed. It was only after NEPA's passage that Federal agencies began to address community lifeway resources in any explicit way, and NEPA remains the primary legal authority for considering such resources. NEPA also caused agencies to develop the infrastructure of the positions, offices, regulations, and guidelines needed to manage other kinds of cultural resources, notably historic real property. The Council on Environmental Quality (40 CFR 1500-08) regulate the policy. The Council encourages combining NEPA documents and procedures with other necessary agency documentation (40 CFR 1506.4).

Federal Agency Responsibilities—"Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;" "preserve important historic, cultural, and natural aspects of our national heritage;" and agencies are directed to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and *social sciences* and the environmental design arts in planning and in decision making..."

National Historic Landmark—While National Register listing may include local, state, or national historical significance, National Historic Landmark status requires national historical significance. All nominations must be reviewed and approved by the National Park System Advisory Board and then by the Secretary of Interior for final designation. The criteria for selection are the same as for National Register, but only the exemplary examples of national significance qualify.

All undertakings that may have an effect on a National Historic Landmark usually must be reviewed by adoption of a Memorandum of Agreement (MOA) or a letter from the Federal agency to the Advisory Council on Historic Preservation.

National Historic Preservation Act of 1966—The National Historic Preservation Act of 1966 (NHPA), as amended in 1980 (P.L. 89-655, 80 Stat. 915; as amended by P.L. 91-243, 84 Stat. 204; P.L. 93-54; P.L. 94-422, 90 Stat. 1313; P.L. 94-458; P.L. 96-199; P.L. 96-244; P.L. 96-515, 94 Stat. 2987; P.L. 98-483; P. L. 99-514; P.L. 100-127, 106 Stat. 4753; 16 U.S.C. 470) is the nation's central historic preservation law. The Act sets forth policy of the U.S. Government regarding historic preservation and promotes conditions in which historic properties can be preserved in harmony with modern society, and fulfill society's needs.

Federal Agency Responsibilities—The Act directs Federal agencies to name "Agency Preservation Officers" to coordinate their historic preservation activities, to seek ways to carry out their activities in accordance with the purposes of the Act, to identify historic properties under their jurisdiction, to consider such properties when planning actions might affect them, to give the Advisory Council an opportunity to comment on such actions, and to document historic properties that cannot be saved. The "Agency Preservation Officer" for the Coast Guard is located at the Department of Transportation Headquarters, Washington, D.C. The Act also established the National Register of Historic Places and the State Historic Preservation Officers, which are described below.

The 1980 amendments included the addition of Section of 110, which articulated broad, affirmative responsibilities in historic preservation for Federal agencies. These amendments also directed the National Park Service to issue regulations governing how Federal agencies would manage, or 'curate', their collections of artifacts recovered from archaeological excavations. These regulations, *36 CFR Part 79*, were published in 1990. They provide the basic standards that Federal agencies must meet in managing their artifact collections. In addition, the amendments specified State Historic Preservation Officer (SHPO) responsibilities and established a special program for participation by local governments. 36 CFR Part 800 was revised and reissued in 1986.

NHPA was amended again in 1992. This amendment strengthened Section 106 review and increased, among several items, the historic preservation responsibilities of Federal agencies including:

- require Federal agencies to have preservation programs with specially defined elements;
- require Federal agencies to have Section 106 procedures meeting specific standard; and
- discourage "anticipatory demolition" of historic properties.

National Register of Historic Places—The National Historic Preservation Act authorizes the Department of Interior to establish, maintain, and expand a National Register of Historic Places. The Register is maintained by the National Park Service; it is a computerized listing of properties that have been nominated and accepted as having historic, architectural, archeological, engineering or cultural significance, at the national, State, or local level. The Register grows steadily as more properties are identified and nominated each year. The National Register is considered the "official list of the Nation's cultural resources worthy of preservation."

A property is eligible for the Register if it meets one or more of the following criteria:

The quality of significance in American history, architecture, archeology, engineering and culture is present in districts, sites, buildings, structures, and objects:

a) that are associated with *events* that have made a significant contribution to the broad pattern of our history; or

b) that are associated with the lives of *persons* significant in our past; or

c) that embody the *distinctive characteristics* of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent significant and distinguishable entity whose components may lack individual distinction; or

d) that have yielded, or may be likely to yield, *information* important in prehistory or history.

In addition, Section 101(d)(6)(A) of the National Historic Preservation Act provides that properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization may be determined to be eligible for inclusion on the National Register.

Besides meeting one or more of the National Register criteria, a property must also have integrity of location, design, setting, materials, workmanship, feeling, and association in order to be eligible for the National Register. This means, in effect, that if a property has been seriously compromised by unsympathetic alterations, it may not be eligible for the National Register. See also:

• National Register Bulletin #15*: "How to Apply National Register Criteria for Evaluation."*

• National Register Bulletin #16 Part A*: "How to Complete the National Register Form."*

• National Register Bulletin #16 Part B*: "How to Complete the National Register Multiple Property Documentation Form."*

These are available from the National Register of Historic Places, National Park Service (NHRE-2280), P.O. Box 37127, Washington, DC 20013-7127.

Preservation—The act or process of applying measures necessary to sustain the existing form, integrity, and materials of a historic structure, landscape, or object. Work may include preliminary measures to protect and stabilize the property, but generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. For historic structures exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

Preservation Maintenance—The action to mitigate wear and deterioration of a historic property without altering its historic character by protecting its condition, repairing when its condition warrants with the least degree of intervention including limited replacement in-kind, replacing an entire feature in kind when the level of deterioration or damage of materials precludes repair, and stabilization to protect damaged materials or features from additional damage. For archeological sites it includes work to moderate, prevent, or arrest erosion. For museum objects it includes actions to prevent damage and to minimize deterioration by practicing preventive conservation or by performing suitable treatments on objects themselves. Types of preservation maintenance are:

Housekeeping—The removal of undesirable deposits of soil in ways that minimize harm to the surfaces treated, repeated at short intervals so that the gentlest and least radical methods can be used.

Preventative Maintenance—Planned, scheduled periodic inspection, adjustment, cleaning, lubrication, parts replacement, and minor repair of features. Preventative maintenance is the cornerstone of a good maintenance program. It extends the life and reduces overall maintenance costs of assets by minimizing wear and catching emerging maintenance problems prior to failures.

Corrective Maintenance—Maintenance work performed to restore a feature to a condition substantially equivalent to its originally intended and designed capacity, efficiency, or capability. Corrective Maintenance is sometimes referred to as repair. It typically corrects deficiencies caused by wear, component failure, and other damage.

Routine Maintenance—All maintenance not specifically corrective or preventative in nature. It includes recurring and ownership functions such as custodial services, maintenance repainting, reglazing windows oiling hardware, etc.

Cyclic maintenance—Maintenance performed less frequently than annually; usually involves replacement or at least mending of material.

Stabilization—action to render an unsafe, damaged, or deteriorated property stable while retaining its present form.

Protection—The action to safeguard a historic property by defending or guarding it from further deterioration, loss, or attack or shielding it from danger or injury. In the case of structures and landscapes such action is generally of a temporary nature and anticipates future preservation treatment; in the case of archeological sites, the protective measure may be temporary or permanent. Protection in its broadest sense also includes long-term efforts to deter or prevent vandalism, theft, arson, and other criminal acts against cultural resources.

Reconstruction—The act or process of depicting, by means of new construction, the form, features, and detailing of a none-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location.

Rehabilitation—The act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.

Restoration—The act or process of accurately depicting the form, features, and character of a historic structure, landscape, or object as it appeared at a particular period of time by means of removal of features from other periods in its history and the reconstruction of missing features from the restoration period.

Section 106 Review, Section 106, or "106"—Refers to Section 106 of the National Historic Preservation Act requires federal agencies including the Coast Guard, DoD, and military services to consider the effects of their proposed actions on historic properties included in or eligible for inclusion in the National Register of Historic Places and gives the independent Federal reviewing agency, the Advisory Council on Historic Preservation a reasonable opportunity to comment on the proposed undertakings.

Stabilization—The intervention treatment action taken to increase the stability or durability of an object when preventive conservation measures fail to decrease its rate of deterioration to an acceptable level or when it has deteriorated so far that its existence is jeopardized.

State Historic Preservation Officer (SHPO)—The National Historic Preservation Act establishes the responsibilities of the State Historic Preservation Officers, the State officials who administer the national historic preservation program at the State level. Each SHPO is responsible for developing a statewide plan for preservation; identifying historic properties; nominating properties to the National Register; and providing technical assistance to Federal, State, and local agencies and the public, participating in the review of Federal undertakings that affect historic properties, among other activities.

Structure—See "Historic Structures"

Undertaking—As referred to in Section 106 of the National Historic Preservation Act, any federal, federally assisted, federally licensed, or federally sanctioned project, activity, or program that can result in changes to the character or use of historic properties. Undertakings include new and continuing projects, programs, and activities that are (1) directly undertaken by federal agencies; (2) supported in whole or in part, directly or indirectly, by federal agencies; (3) carried out pursuant to a federal lease, permit, license, approval, or other form of permission; or (4) proposed by a federal agency for congressional authorization or appropriation. Undertakings may or may not be site-specific. (See 36 CFR 800.2[o] and Section 301(7) of the National Historic Preservation Act.

Technical Terms

'As-Built'—Refers to drawings or conditions at the completion of construction that record any modifications or deviations from the original construction plans or drawings; existing configuration of the structure (lighthouse).

Balustrade—An entire railing system (as along the edge of a balcony) including a top rail and its balusters, and sometimes a bottom rail.

Berm—A wall or mound of earth

Chamfer—1. A bevel or cant, such as small splay at the external angle of a masonry wall. 2. An oblique surface produced by beveling an edge or corner, usually at a 45° angle, as the edge of a board or masonry surface.

Cladding—A layer of metal bonded to another material for strength and protection.

Consolidants—A hardening liquid that will increase the strength of deteriorated material whose integrity has been compromised because of the degradation.

Cornice—1. Any molded projection which crowns or finishes the part to which it is affixed. 2. The exterior trim of a structure at the meeting of the roof and wall, usually consists of bed molding, soffit, fascia, and crown molding.

Dormer—A structure projecting from a sloping roof, usually housing a window or ventilating louver.

Eave—The lower edge of a sloping roof; that part of a roof of a building that projects beyond the wall.

Ell—A secondary wing or extension of a building at right angles to its principal dimension.

Epoxy—Designating or of a compound in which an oxygen atom is joined to each of two attached atoms, usually carbon; specifically, designating any of the various thermosetting resins, containing epoxy groups, that are blended with other chemicals to form hard, strong, chemically resistant substances used as adhesives, enamel coatings, etc.

Extant—Still existing, not extinct, not lost or destroyed.

Fabric—The basic elements making up a building; the carcass without finishes or decoration.

Fascia—Any flat horizontal member with little projection.

Faux-graining—A type of decoration where surfaces are painted in such a way to simulate natural looking wood grain.

Fenestration—The arrangement of windows and doors in a building; an opening in a wall.

Filler—A preparation used to fill in the cracks, grain, etc., of wood before painting or varnishing.

Frustum—A figure consisting of the bottom part of a cone or pyramid, the top of which has been cut off by a plane parallel to the base. The conical portion of a lighthouse is considered a *frustum*.

Guano—Manure of birds.

'In-kind'—The preservation practice of limited replacement using matching materials in type, species, and configuration.

Light—1. An aperture through which daylight is admitted to the interior of a building. 2. Pane of glass, a window. 3. The illuminating fixture of a lighthouse, i.e., light bulb, lamp, etc.

Mullion—A slender, vertical dividing bar between the lights (or panes) of windows, doors etc.; a vertical member separating (and often supporting) window, door, or panels set in a series.

Muntin—A secondary framing member to hold panes within a window, window wall, or glazed door; an intermediate vertical member that divides the panels of a door.

Patina—1. A fine crust or film on bronze or copper, usually green or greenish-blue, formed by natural oxidation and often valued as being ornamental. 2. Any thin coating or color change resulting from age.

Pointing—1. In masonry, the final treatment of joints by the troweling of mortar into the joints between the masonry units (bricks, stones, etc.). 2. The material with which the joints are filled.

P.S.I.—Pounds per Square Inch: a unit used to measure pressure.

Quantity Take-off—The practice of accounting individual elements, components, and units of a structure for purposes of a detailed cost estimate for construction purposes.

Rabbet—A longitudinal channel, groove, or recess cut out of the edge or face of a member, especially one to receive another member, or one to receive a frame inserted in a door or window opening, or the recess into which glass is installed in a window sash.

Rising damp—A phenomenon where moisture rises through a masonry wall above grade because of capillary action in the masonry units.

Rust-jacking—Deformation that is the result of rusting iron. The 'jacking' is the result of the chemical change that takes place when iron corrodes or rusts. As the iron rusts it changes from iron to iron oxide; this change is the result of the oxygen carried in water combining with the iron. The iron oxide which results takes up more volume than the iron. The force of this expansion is strong enough to crack glass and force steel components apart.

Sistering—A technique of structural stabilization or reinforcement where the extant member is reinforced by attaching a stronger member along its span.

Soffit—The exposed undersurface of any overhead component of a building, such as a arch, balcony, beam, cornice, lintel, or vault.

Spalling—The exfoliation of layers of a material, especially bricks, where the layers break off parallel to the face of the material.

Lighthouse Specific

ANT—**<u>A</u>id to <u>N</u>avigation <u>T</u>eam**—United States Coast Guard term and title given to the typically small units responsible for the care and maintenance of the majority of the Coast Guard's fixed aids to navigation: lighthouses, range lights, etc.

ATON—**<u>A</u>id <u>To</u> <u>N</u>avigation**—United States Coast Guard term used to describe any device used as an aid to navigation such as lighthouses, range lights, buoys, etc.

Astragals—Vertical members that retain the storm panels in the frame of the lantern, typically made of bronze.

Balcony—The exterior walkway around a lantern room or watch room on a light tower.

Caisson—1. A watertight enclosure inside which underwater construction work can be done. 2. An offshore lighthouse type, so called because a caisson is used during the construction of the lighthouse foundation.

Cellar—The lower chamber of a caisson type lighthouse, typically houses cisterns, fuel tanks and other storage.

Clamps—Horizontal members that retain the storm panels at the top and bottom, typically made of bronze.

Davit—Either of a pair of uprights that can be swung out over the side of a water-based lighthouse for lowering or raising a small boat.

Daymark—A distinctive pattern painted on the exterior of a lighthouse, used by mariners during daylight navigation. In many cases, the lighthouse structure itself is considered a daymark.

Fixed Light—A steady, non-flashing beam.

Focal plane—The level plane at which the lighthouse's or range light's lens is focused; the height of this plane is measured from mean sea level.

Fog signal—See "sound signal"

Fresnel lens—A system of annular prisms that refract and reflect into a beam; invented in 1821 by Augustine Fresnel; this system captures and focuses up to 70% of the light emitted from the illuminant. Fresnel designed a variety of lens system sizes which he defined by orders. Today, there are 9 modern equivalents to his original orders, first through sixth (including a 3½ order), a meso radial, and hyper radial. The first-order lens is the largest and is typically used in coastal lights. The sizes of the lenses and their effective range decrease as the order number increases.

Gallery deck—The exterior walkway outside the lantern.

Keeper—The person in charge of maintaining the light station and attending the optic.

Lamp—The oil lighting apparatus inside a lens. A lamp was used before electricity powered the illuminant.

Lantern—The portion of the lighthouse structure that houses and protects the lens and illuminant; relative size described/defined by the size of the lens based on the 7 Fresnel orders. Also referred to as the lantern room.

Lantern deck—Interior deck of large first- through third-order lanterns; encircles lens to provide access for maintenance and cleaning.

Lantern glass–Glass panes in the lantern that protect the lens and illuminant while allowing the maximum amount of light to pass. Also referred to as "lantern glazing."

Lens—Any glass or transparent material that is shaped to focus light.

Lighthouse—A fixed aid to navigation located at some place important or dangerous to navigation which was historically kept by a resident keeper; it has a very bright light at the top and is often outfitted with foghorns, sirens, etc., by which ships are guided or warned.

Light Station—Refers not only to the lighthouse but to all the buildings at the installation supporting the lighthouse including keepers quarters, oil house, fog signal building, cisterns, boathouse, workshop, etc. Some light stations have had more than one lighthouse over time.

Lighthouse Tender—Ship used to supply the light and fog signal stations, maintain buoys, and service lightships. Today, similar vessels are called buoy tenders.

Lightship—A moored vessel which marked a harbor entrance or a dangerous projection such as a reef where lighthouses could not be constructed. Eventually replaced with "Texas Towers" and large navigational buoys. The Coast Guard no longer maintains any active lightships.

Oil house—A small building, usually made of stone or concrete, which stored oil for lighthouse lamps. Oil houses were built after kerosene, a highly flammable agent, came into use as an illuminant.

Parapet—In third- through sixth-order lighthouses, the low wall in the lantern room that supports the storm panel frame and roof.

Privy—An outbuilding used as a toilet; an outhouse.

Radiobeacon—A radio-sending device which transmits a coded signal by which a mariner can determine his or her position using a radio-direction-finding apparatus. The only radiobeacons being retained by the Coast Guard are those that will be used to transmit Differential GPS signals.

Range lights—Pairs of fixed aids that are typically used to guide ships into or through channels; the lights are typically defined by upper and lower positions; when the lights are aligned as described in the USCG light list, the mariner will know his position relative to the channel.

Screwpile—1. A type of piling fitted with a helical fluke that is twisted into the bottom of a body of water. 2. A lighthouse type that employs screwpilings as a primary foundation system.

Sound Signal–A device used to provide a loud patterned sound during foggy weather to aid mariners in establishing their position or to warn them away from a danger. Also referred to as the "fog signal"; types include bells, whistles, sirens, reed trumpets, diaphone and diaphragm horns, and electric horns.

Storm panels —The term used by the U.S. Lighthouse Board for emergency or temporary glazing. Historically, storm panels were kept on hand and fitted to the interior of the lantern when the primary glazing was broken in a storm and needed immediate repair.

Tower—The portion of the lighthouse that supports the lantern.

Ventilation ball—The perforated spherical ball at the apex of the lantern roof that originally provided ventilation for the oil-fired illuminant.

Organizations

Preservation Related

Advisory Council on Historic Preservation (see glossary for description)
1100 Pennsylvania Ave. NW, Suite 809
Washington, DC 20004
(202) 606-8503; Fax: (202) 606-1172
Office of Education and Preservation (202) 606-8505

Western Review Office
730 Simms Street, #401
Golden, Colorado 80401
(303) 231-5320

American Institute of Architects
Historic Resources Committee
1735 New York Avenue, N.W.
Washington, D.C. 20006
(202) 626-7457/ 7418, (800) 242-3837
Or check in the yellow pages under architects for the closest chapter

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017
(212) 705-7220

American Society of Landscape Architects
4401 Connecticut Avenue, N.W.
Washington, D.C. 20006
(202) 686-2752

Association for Preservation Technology International (APT)
P.O. Box 3511
Williamsburg, VA 23187
(703) 373-1621

Construction Specifications Institute
600 Madison Street
Alexandria, Virginia 22314-1791
(703) 684-0300

National Historical Publications and Records Commission (NHPRC)
National Archives Building, Room 607
Washington, D.C. 20408
(202) 501-5610

National Park Service

Archeology and Ethnography Program
National Park Service (2275)
1849 C Street, NW
Washington, DC 20240
(202) 343-4101

Heritage Preservation Services
National Park Service (2255)
1849 C Street, NW
Washington, D.C. 20240
(202) 343-9565, Fax: (202) 343-3803

Historic Preservation Training Center
The Gambrill House
4801 Urbana Pike, #A
Frederick, MD 21704
(301) 663-8206; Fax: (301) 663-8032

National Center for Preservation Technology and Training
108 Kyser Hall
Northwestern State University of Louisiana
NSU Box 5682
Natchitoches, LA 71497
(318) 357-6464; Fax: (318) 357-6421

National Register of Historic Places
National Park Service (2280)
1849 C Street, NW
Washington, D.C. 20240
(202) 343-9500

National Trust for Historical Preservation
1785 Massachusetts Avenue, N.W.
Washington, D.C. 20036
(202) 673-4000; Fax: (202) 673-4059

Society of American Military Engineers
607 Prince Street
Alexandria, VA 22314
(703) 549-3800

Society of Architectural Historians
1365 N. Astor Street
Chicago, IL 60610-2144
(312) 573-1365

Lighthouse Specific

U.S. Lighthouse Society
244 Kearny Street - 5th Floor
San Francisco, CA 94108
(415) 362-7255
USLHS provides its members with *Keepers Log*, an illustrated quarterly journal, lighthouse tours, and a general information service on lighthouse and lightship preservation

Great Lakes Lighthouse Keepers Association
Henry Ford Estate
4901 Evergreen Road
Dearborn, MI 48128
(313) 436-9150
GLLKA provides its members with a quarterly journal and hosts annual meetings

Lighthouse Preservation Society
4 Middle Street
Newburyport, MA 01950
(800) 727-2326
(508) 499-0011
LPS is largely an advocacy and fundraising group for lighthouse preservation issues and projects; membership includes the monthly magazine *Lighthouse Digest*.

National Maritime Initiative
National Park Service (NRHE-2280)
1849 C Street, NW
Washington, DC 20240
(202) 343-9508; Fax: (202) 343-1244
e-mail: candace_clifford@nps.gov

The Initiative maintains a database of historic light stations around the U.S.

Nautical Research Centre
335 Vallejo Street
Petaluma, CA 94952
(707) 763-8453
Library containing over 1000 books and plans relating to both the U.S. Lighthouse and Lifesaving Services

Record Group 26
National Archives
Washington, DC 20408
Record Group 26 includes records of the Bureau of Lighthouses and it predecessors, 1789-1939; U.S. Coast Guard records from 1828 to 1947; as well as cartographic and audiovisual materials from 1855 to 1963. (See description of holdings later in this section)

U.S. Coast Guard

Historian's Office G-CP-4
Headquarters, U.S. Coast Guard
2100 2nd Street, S.W.
Washington, DC 20593
The Coast Guard History Office maintains operational records and historical materials relating to the U.S. Coast Guard and its predecessor agencies.

Federal Preservation Contact:
Chief, Environmental Management Division
Office of Civil Engineering COMDT (G-SEC-3)
Headquarters, U.S. Coast Guard
2100 2nd Street, SW
Washington, DC 20593-0001

U.S. Coast Guard Civil Engineering Units:

Commander
Maintenance and Logistics Command Atlantic
300 East Main Street
Norfolk, VA 23510

Commanding Officer
Civil Engineering Unit Miami
Brickell Plaza Federal Bldg.
15609 S.W. 117 Avenue, Suite A
Miami, FL 33177

Commanding Officer
Civil Engineering Unit Cleveland
1240 E. Ninth Street
Cleveland, OH 44199-2060

Commanding Officer
Civil Engineering Unit Providence
300 Metro Center Blvd.
Warwick, RI 02886

Commander
Maintenance and Logistics Command Pacific
Coast Guard Island
Alameda, CA 94501-5100

Commanding Officer
Civil Engineering Unit Oakland
2000 Embarcadero, Suite 200
Oakland, CA 94606-5337

Commanding Officer
Civil Engineering Unit Juneau
P.O. Box 21747
Juneau, AK 99802-1747

Commanding Officer
Civil Engineering Unit Honolulu
Prince Kalanianaole Federal Building
300 Ala Moana Blvd., Room 8122
Honolulu, HI 96850-4982

World Wide Web

For more information on publicly accessible lighthouses, visit the National Maritime Initiative's site on the World Wide Web. The internet address for this NPS site is http:/www.cr.nps.govhistory/maritime/ltaccess.html
For a listing of lighthouse internet sites around the world, visit http://www.maine.com/lights/www_vl.htm

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59 South Prospect Street
Hartford, Connecticut 06l06
860-566-3005; Fax: 203-566-5078

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Mr. Daniel R. Griffith
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Hall of Records
P. O. Box 1401
Dover, Delaware 19901
302-739-5313; Fax: 302-739-6711

Delaware State Historic Preservation Office
#15 - The Green
Dover, DE 19901

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All documents requiring immediate attention should be faxed to James F. Hall or Dorthy Guzzo, DSHPO.

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Preparing a National Register Nomination

Where to Start: Before one begins to prepare a National Register Nomination, contact the State Historic Preservation Office (SHPO) of the State in which your property is located (and/or the Federal Preservation Officer if the owner is a federal agency) to receive appropriate forms, instructions, and guidance (a list of SHPOs and the Coast Guard FPO are found earlier in this section). Nomination forms are generally available both in paper and computer disk formats. Your SHPO and or FPO can save you time and frustration. SHPOs can also inform applicants if the community where the property is located is a Certified Local Government (CLG) and has a preservation officer who also can provide information and assistance. SHPOs have an important role in the nomination process. They review all documentation on the property, schedule the property for consideration by the state review board, and notify property owners and public officials of the meeting and proposed nomination. The SHPO makes a case for or against eligibility at the board's meeting, and, considering the board's opinion, makes the final decision to nominate the property. The SHPO also comments on nominations and determinations of eligibility requested by federal agencies.

Guides to assist in preparing a National Register Nomination:

- National Register Bulletin #15: "How to Apply National Register Criteria for Evaluation." Bulletin #15 is a detailed discussion of each criteria which may be used for nominating a structure to the National Register including specific examples which qualify and others which do not. It should be used by anyone who is 1) preparing to nominate a property to the National Register, 2) seeking a determination of a property's eligibility, 3) evaluating the comparable significance of a property to those listed in the National Register, or 4) expecting to nominate a property as a National Historic Landmark (includes a summary of Landmark Criteria for Evaluation) in addition to nominating it to the National Register.
- National Register Bulletin #16 Part A: "How to Complete the National Register Form." Part A is a step-by-step how-to approach guide including a section on "Getting Started." It provides information on 1) how to identify and locate nominated properties as per National Register requirements, 2) how the property meets one or more of the National Register criteria, and 3) how to make a case for the historic significance and integrity.
- National Register Bulletin #34: "Guidelines for Evaluating and Documenting Historic Aids to Navigation." Bulletin #34 has specific information geared to nomination of lighthouses including examples of descriptive text and statement of significance.
- National Register Bulletin #39: "Researching a Historic Property."

These bulletins are available from the National Register of Historic Places, National Park Service (2280), P.O. Box 37127, Washington, DC 20013-7127.

Steps in Research

The SHPO will be able to determine if the property has already been listed on the state's or some other inventory and possibly provide information about significant historic contexts and documentation that may be useful in researching a property. Remember that researching a historic property for National Register nomination differs from researching a property for other purposes. Information collected must be directed at determining the property's *historical significance*. When evaluating a property against National Register criteria, significance is defined as the importance of a property to the history, architecture, archeology, engineering, or culture of a community, a state, or the nation. Every National Register nomination must place a property in its *historic context* to support that property's significance.

Two other considerations affect evaluations of significance: *association* and *period of significance*. Association refers to a direct connection between the property and the area of significance for which it is nominated. Period of significance refers to the span of time during which significant events and activities occurred. Events and associations with historic properties are finite; most properties have a clearly definable period of significance. Lastly, a property is evaluated for its *integrity*. Integrity is the authenticity of physical characteristics from which properties derive their significance. A lighthouse depends upon a number of specialized ancillary buildings, and most light towers were originally part of such a complex which included the keepers quarters, oil house, fog signal, storage sheds, boat house, and in later years radio beacons. Lighthouses where ancillary buildings and structures have been destroyed will have difficulty meeting integrity requirements. Bulletin #39 is written specifically to assist the beginner who is researching a National Register nomination. It includes basic sources and techniques for the collection of data and should be used in conjunction with Bulletin #16.

One of the most challenging tasks facing a researcher is knowing when enough material has been gathered. As Bulletin #39 points out, a National Register nomination can usually be completed when the following questions can be answered:

- What was the property called at the time it was associated with the important events or persons, or took on the physical character that gave it importance?
- How many buildings, structures, and other resources make up the property?
- When was the property constructed and when did it attain its current form?
- What are the property's historic characteristics?
- What changes have been made over time and when? How have these affected its historic integrity?
- What is the current condition of the property, including the exterior, grounds, setting, and interior?
- How was the property used during its period of significance, and how is it used today?
- Who occupied or used the property historically? Did they individually make any important contributions to history? Who is the current owner?
- Was it associated with important events, activities, or persons?
- Which of the National Register criteria apply to the property? In what areas of history is the property significant?
- How does the property relate to the history of the community where it is located?
- How does the property illustrate any themes or trends important to the history of its community, state, or the nation?
- How large is the property, where is it located, or what are its boundaries?
- Would this property more appropriately be nominated as part of a historic district?

To save time and frustration, organize research tasks in an efficient and logical fashion. Decide what needs to be known and where to find it. Make a list of the questions to answer. Make a list of specific tasks, noting where to go, to whom to speak, what to look for, and the order in which to proceed. Determine your possibilities and limitations. Identify what historic information is readily available, perhaps in the collections of current or previous owners, a neighbor, or the community. As early as possible, establish the construction date for the property. This date may help establish an earliest beginning date for the period of significance. In addition, try to discover the names by which the property and/or lighthouse has been known through its history, so as not to overlook information under an unfamiliar name. Save time and effort by defining the parameters of the project in advance. Questions and tasks can be altered, discarded, or added as the research proceeds. Once you know exactly what you need to find, and have a good idea of where to find it, you are well on your way to accomplishing your goal. Bulletin #39 includes a general guide to research sources including abstract of title, architectural/construction drawings, building permits, court documents, deeds, land records, maps and plats, federal records, newspapers, photographs, and postcards.

Textual and Non-textual Historic Resources

Start with local libraries, historical societies, and museums collections. Often, photographs, letters, and other materials not available anywhere else show up at these sources. Check newspapers (clipping files or microfilm) for information. Lighthouses were big news and articles almost always appeared when lighthouses were built, damaged, decommissioned, or other significant events occurred.

The National Archives, Washington, D.C., has the largest and most complete collection of books, documents, photographs, plans, and other printed resources relating to lighthouses in the United States (see "National Archives Historical Resources" on page 33 of this section). Copies of the *Light Lists* and *Annual Reports* can be found at the Library of Congress; National Archives; USCG Historians Office, Headquarters, Washington, D.C.; USCG Academy Library, New London, Connecticut; Mariner's Museum, Newport News, Virginia; The Peabody Museum, Phillips Library, Salem, Massachusetts; J. Porter Shaw Library, San Francisco Maritime National Historical Park, San Francisco; the Nautical Research Center, Petaluma, California; and the U.S. Lighthouse Society, San Francisco, California. The library at the U.S. Navy Historical Center, Washington, D.C., has some scarce material not found in the libraries mentioned above.[1]

There are hundreds of books written about lighthouses. Two of the better ones are George R. Putnam's *Lighthouses and Lightships of the United States* (Boston: Houghton Mifflin, 1917) and Francis Ross Holland, Jr.'s *America's Lighthouses: An Illustrated History* (New York: Dover Publications, Inc., 1988). Putnam was commissioner of lighthouses for about 25 years and Holland was supervisory research historian and associate director for cultural resources management for the National Park Service. In recent years regional lighthouse guides have become very popular, but the histories they provide are usually very brief and often inaccurate.

Historic photographs, postcards, and other graphics should be researched to document how a property has changed and/or retained its original character over time. Often times these sources are the only means of determining what outbuildings looked like, where they were located, or moved.

Historical research is time consuming and often frustrating. It is not unusual to find conflicting information. Rely on primary sources; long-held local traditions and popular publications are often inaccurate. A good historian seeks the truth. Professional historians can be contracted to do this work for you. A thorough research will almost always involve a trip to Washington, D.C., with visits to the

[1] Much of this resource information is from Francis Ross Holland, Jr., *America's Lighthouses: An Illustrated History*, New York, Dover Publications, Inc., (1988), pp. 225-226.

National Archives and Coast Guard Historian's Office.

Oral History

If possible, interview surviving keepers, Coast Guard individuals, or other Federal agency managers who worked at the lighthouse/light station, and other persons such as neighbors and relatives. While memories are not as dependable as primary written records such as logs and diaries, oral histories are often the only source of what life was like at a station. Often, during interviews, photographs, newspaper clipping, mementoes, etc. will be brought out, which may contribute to the history of a property. A good place to begin oral history research, especially if you are a beginner, is to obtain *Documenting Maritime Folklife: An Introductory Guide*[2].

Field Work

Remember that the property itself is a primary source of information. Walk through the property and gather information that describes it, noting distinctive features and obvious alterations and changes. Examine all buildings and structures, inside and out. Examine the grounds, noting any signs of previous buildings or activities (foundations, wells, etc.), and roadways, paths, vegetation, fences, and other features. Adequate field examination of a lighthouse and/or light station may involve more than one visit to acquire a thorough understanding of it's construction, equipment, and layout. A guided tour by a knowledgeable individual such as the aids to navigation officer of the Coast Guard, as well as the crews who maintain it, is often valuable.

Documentation

Black and white photographs as well as color slides of the lighthouse/light station should be taken from many angles both inside and out. Each elevation of a structure should be included, as well as details of specific architectural features, equipment, etc. Overall shots showing the relationship of different buildings and the surrounding landscape are also useful. Each photograph should be identified with subject, photographer, date, and source. A sketch map showing the positions where photographs were taken are also very helpful. Historic photos, if available should be included with the nomination.

Keep field notes, research notes, and sketches. Reproduced reference material, photographs, postcards, deeds, maps, plats, etc. should be compiled. Chronologically arrange the files to help understand the progression and nature of change which took place at the property over time. Color slides and/or photographs are useful references when preparing the National Register nomination, especially if returning to the site to check on a detail is difficult and/or impossible. Footnote or endnote all your sources of information. Try to use primary sources; secondary sources are notorious for being inaccurate. Nearly every lighthouse in the south during the Civil War is reputed to have been shot at, the light lens buried in the sand to hide it from the Yankees, and/or escape tunnels dug; yet very few such claims are factual.

Determining Architectural Significance

A lighthouse may be significant because it is: 1) a good representative of a specific style of architecture, such as Eastlake or

[2]David Taylor, *Documenting Maritime Folklife: An Introductory Guide* (Washington, D.C., Government Printing Office, 1992).

Eastern Stick Style; 2) a good representative of specific construction type, such as a screwpile, caisson, or crib foundation lighthouse; and 3) a good example of the work of a famous architect such as Cape Henry (old) Lighthouse.

Archeological Documentation

Archeological documentation can add to or revise the understanding of the history of the lighthouse/light station by documenting the poorly recorded or undocumented archeological aspects of a lighthouse, such as the layout and construction. Archeological resources not associated with the station, such as prehistoric sites, can enhance the significance of a nomination. When significant archeological resources are known to exist at a site, the nomination should clearly demonstrate that the archeological information, if and when obtained from the site, may significantly supplement or revise current historic or archeological knowledge or understanding.

When documenting the archeological features of a lighthouse, the nomination should stress how the site is known to possess archeological remains, such as through remote sensing or archeological test excavation. The documentation of no-longer-extant lighthouses, including missing or earlier buildings and structures at existing lighthouses, should include descriptions and characteristics determined through archival research that are then assessed, verified, or contrasted with the actual physical, archeological resource. Archeological documentation should include a site plan showing where excavation units were placed and drawings of exposed features (such as a lighthouse foundation or a deposit of material culture in a trash pit). Include photographs of archeological features or significant artifacts.

In most cases archeological documentation through excavation will not be required for a National Register nomination. However, if such excavation is contemplated, always contact your SHPO first, and never undertake such work without using qualified, trained professionals. Once a site is excavated the evidence it held cannot be replaced. Your SHPO can assist you in finding such professional assistance. Documentation of foundations may not require excavation and can be carried out without professional assistance so long as the site is not destroyed or altered.

Choosing an Appropriate Treatment for a Historic Lighthouse Project

The *Standards* are neither technical nor prescriptive, but are intended to promote responsible preservation practices that help protect our Nation's irreplaceable cultural resources. They cannot be used to make essential decisions about which character-defining features of a historic lighthouse should be retained and which can be changed. Once a specific treatment is selected, the *Standards* can provide the necessary philosophical framework for a consistent and holistic approach to a historic lighthouse project.

A treatment is a physical intervention carried out to achieve a historic preservation goal; it cannot be considered in a vacuum. There are many practical and philosophical variables that influence the selection of a treatment for a lighthouse. These include, but are not limited to, determination of the ultimate treatment, relative significance, integrity and existing condition, use, context, archeological resources, management and maintenance, interpretation, and mandated code requirements. Therefore, it is necessary to consider a broad array of dynamic and interrelated variables in selecting a treatment for a historic lighthouse preservation project.

Ultimate treatment: The ultimate treatment of a historic structure is a general definition of its development limits based on considerations of use and the historic character that should be preserved. It is accomplished through one or more construction projects, after which the structure is preserved by preservation maintenance. Subsequent rehabilitation or restoration may be needed to update the structure's functional aspects and to repair or replace damaged or deteriorated features. The restoration of a lighthouse may include partial dismantling and/or reconstruction of missing or deteriorated features to return it to its appearance at a specific moment in history. Restoration, in this case, would become the ultimate treatment because after it is completed, all future treatments would be considered maintenance.

The Old Cape Henry Lighthouse (first tower) is a good example of a historic lighthouse that has reached its ultimate treatment through restoration. The masonry has been preserved and the lantern has been reconstructed. Future activities such as replacement of deteriorated masonry blocks, work to enhance the lantern, or installation of a reproduction lens would all contribute to the restoration.

Pending ultimate treatment, a lighthouse should be stabilized and protected in its existing condition; it may also receive an interim treatment compatible with its planned appearance and use. Choosing the most appropriate treatment for a building requires careful decision-making about it's historical significance, as well as taking into account a number of other considerations.

Interim treatment—Mothballing: Whereas a restoration or reconstruction, or even a rehabilitation project, would usually be considered an ultimate treatment, one must also consider an interim treatment. For historic lighthouses an interim treatment may be the best way to achieve a satisfactory level of maintenance and security while a larger, more comprehensive project is in the planning or fund-raising stages. Both preservation and mothballing can be considered interim treatments. When a lighthouse needs to be made weathertight and secure and is *not* open to the public, mothballing is generally considered. Mothballing addresses immediate critical maintenance and security needs such as severely leaking roofs, missing or broken windows, lack of protection from vandalism, dangerously deteriorated exterior elements, or possible structural failure. Often, these types of issues can be immediately addressed at a cost less than preservation for a period of three to five, or even ten years depending on the quality of the repairs. In mothballing, materials would likely be repaired rather than replaced, and temporary, reversible fixes would be used rather than making permanent repairs (windows may be outfitted with ventilation louvres rather than replacement of missing glazing, roofs might be patched rather than replaced). Mothballing should be thought of as a way to "buy time" for a longer term project. While often thought of as a "band-aid treatment" mothballing is a legitimate level of treatment when preservation is forthcoming. Mothballing should not be thought of as an ultimate treatment but should be considered a safeguard against the immediate threats of a coastal environment and isolated locations.

While preservation can also be considered an interim treatment if the ultimate goal is a complete restoration or rehabilitation to some other use, such as making a lighthouse into an inn. Preservation would address the same issues as mothballing but would deal with them in a more permanent manner (windows might be reglazed but ventilation louvres would be incorporated into the design, roofs might be partially replaced or a new roof installed, rather than patching).

Relative significance: Is the lighthouse a nationally significant resource—a rare survivor or the work of a master craftsman or architect? Did an important event take place in it? National Historic Landmarks, designated for their "exceptional significance in American history," or many structures individually listed in the National Register of Historic Places are recognized as warranting preservation or restoration. Structures that contribute to the significance of a historic district but are not individually listed in the National Register more frequently undergo rehabilitation for a compatible new use.

Integrity and existing condition: Before selecting a treatment, it is important to understand and evaluate the difference between integrity and existing conditions. Integrity is the authenticity of a lighthouse's historic identity; it is the physical evidence of its significance. Existing conditions can be defined as the current physical state of the lighthouse's form, features, details, and materials. For example, the integrity of an abandoned lighthouse may be intact based on its extant form, features, details, and materials dating from the original construction or period of historic significance, but its existing condition may be poor because of neglect or deferred maintenance.

What is the existing condition—or degree of material integrity—of the structure before treatment? Has the original form survived largely intact or has it been altered over time? Are the alterations an important part of history? Preservation may be appropriate if distinctive materials, features, and spaces are essentially intact and convey the structure's historical significance. If the structure requires more extensive repair and replacement, or if alterations or additions are necessary for a new use, then rehabilitation is probably the most appropriate treatment. These key questions play major roles in determining what treatment is selected.

Use: Historic, current, and proposed use of a historic lighthouse must be considered before treatment selection. Historic use is linked to its significance, while current and proposed use(s) can affect integrity and existing conditions. Parameters may vary from one lighthouse to another. For example, in one lighthouse, continuation of the historic use can lead to changes in the physical form to accommodate new technologies and equipment, i.e., replacement of historic lenses with newer lighting apparatus, or the addition of radar equipment on active aids to navigation. In others, new uses may be adapted within the existing form, features, and details, i.e., converting a historic lighthouse to an inn, visitor contact facility, or museum.

An essential, practical question to ask: Will the structure be used as it was historically or will it be given a new use? Many historic structures can be adapted for new uses without seriously damaging their historic character; special-use properties such as grain silos, forts, windmills, or lighthouses may be extremely difficult to adapt to new uses without major intervention and a resulting loss of historic character and even integrity.

Many historic structures directly support operational functions by serving as visitor centers, administrative offices, housing or lodgings. Some such uses follow historical precedents; others are new adaptive uses. The primary preservation issue in either case is the compatibility of the use with the structure. Considerations include location, access, wear patterns, adequacy of space and spatial configurations, the need for new electrical, mechanical, or ventilation systems, increases in fire risk, and changes necessary to accommodate disabled employees or visitors. Federal agencies are required by law to consider the use of historic structures before the construction of comparable new facilities.

Context: The surroundings of a lighthouse, whether in an urban area, remote coastal location, on an island, or surrounded by water contribute to its integrity and historic character and should be considered before treatment. The context may include other features or structures which fall within the property's historic boundaries. Grounds surrounding a historic lighthouses may bear evidence of the existence and location of earlier associated structures, gardens, walkways, flagpoles, radio tower foundations, etc., dating from the earliest use of the site as a light station. Often these "features" are removed in later years and are lost, but by preserving the grounds and treating the grounds as part of the light station these clues will be saved for future research needs (see **Grounds** section in Part IV).

Archeological resources: Prehistoric and historic archeological resources may be found in the vicinity of historic lighthouses, above and below the ground and even under water. Examples of prehistoric archeological resources include prehistoric mounds built by Native Americans; these are found quite often in coastal zones. Examples of historic archeological resources include foundations of associated lighthouse structures, and other features including fences, walkways, garden plots, or the remains of a wharf, boat dock, or pier. These resources not only have historical value, but reveal significant information about life at a historic lighthouse or station. The appropriate treatment of a historic lighthouse may include the identification and preservation of significant archeological resources.

Management and maintenance: Management strategies are long-term and comprehensive. They can be one of the means for implementing a historic lighthouse preservation plan. Maintenance tasks can be day-to-day, seasonal, or cyclical activities which are part of management strategies. Although maintenance activities, such as replacing broken glass and reglazing window sash, or general lighthouse maintenance, such as upgrading electrical systems or reroofing, may appear routine, such activities can have a cumulative effect on the lighthouse, altering its character. Contrariwise, well conceived management and maintenance activities can sustain character and integrity over an extended period. Therefore, both the management and maintenance of historic lighthouses should be considered when selecting a treatment.

Interpretation: Interpretation can help in understanding and "reading" the historic lighthouse. The tools and techniques of interpretation can include guided tours, self-guided brochures, exhibits, and wayside stations. When considered as a management objective, interpretive goals should compliment treatment selection, reflecting the lighthouse's significance and historic character. A lighthouse/light station may possess varying levels of integrity or even different periods of significance, both of which can result in a multifaceted approach to interpretation.

Mandated code requirements: Regardless of the treatment, code requirements should be taken into consideration. If hastily or poorly designed, a series of code-required actions may jeopardize a structure's materials as well as its historic character. Thus, if a lighthouse must be structurally upgraded, modifications to the historic appearance should be minimal. Abatement of lead paint and asbestos within historic buildings requires particular care if important historic finishes are not to be adversely affected. Finally, alterations and new construction needed to meet accessibility requirements under the Americans with Disabilities Act of 1990 should be designed to minimize material loss and visual change to a historic structure.

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Fact Sheet: A Five-Minute Look at Section 106 Review. 4 pp. April 1989. Briefly explains the five steps in the review process: identification and evaluation of historic properties, assessment of effects, consultation, Council comment, and proceeding with action.

Section 106, Step-by-Step. 63 pp. October 1986. A detailed document that walks the reader through each step of the Section 106 review process in 36 CFR Part 800.

Preparing Agreement Documents. 88 pp. September 1989. For use in preparing memoranda of agreement, programmatic agreements, and conditioned determinations of "no adverse effect."

Identification of Historic Properties: A Decisionmaking Guide for Managers. 25 pp. September 1988. Sets out basic principles and approaches that should be considered when agency officials design an effort to identify historic properties; discusses their application.

Public Participation in Section 106 Review: A Guide for Agency Officials. 21 pp. February 1989. Presents public participation principles, criteria for evaluating existing public participation programs, methods of public participation, and documentation of public participation efforts.

The Section 110 Guidelines: Annotated Guidelines for Federal Agency Responsibilities under Section 110 of the National Historic Preservation Act. 56 pp. November 1989. Guides implementation of Section 110, whereby federal agencies must carry out their programs in accordance with national historic preservation policy, designate historic preservation officers, identify and preserve historic properties under their ownership or control, and try to minimize harm to national historic landmarks.

Fact Sheet: Programmatic Agreements under Section 106. 8 pp. August 1988. Provides background information on programmatic approaches to project review, explains when programmatic agreements are appropriate, and discusses such matters as initiating PAs and public participation in PA development.

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Bulletin 6: Nomination of Property Significant for Association with Living Persons. Rev. 1982. Discusses when it is appropriate to nominate properties whose historical associations are with living persons.

Bulletin 12: Definition of National Register Boundaries for Archeological Properties. 1985. Using case studies, recommends approaches for delineating boundaries for commonly encountered archeological properties.

Bulletin 14: Guidelines for Counting Contributing and Noncontributing Resources for National Register Documentation. Rev. 1986. Provides guidance for distinguishing and counting contributing and noncontributing resources composing a documented property, regardless of size or complexity.

Bulletin 15: How to Apply the National Register Criteria for Evaluation. Rev. 1991. Explains how the NPS applies the criteria used to determine the eligibility of properties for listing in the National Register.

Bulletin 16: Guidelines for Completing National Register of Historic Places Forms. Rev. 1990. Part A provides information on completing the National Register Registration Form; Part B provides information on completing the Multiple Property Documentation Form.

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Bulletin 32: Guidelines for Evaluating and Documenting Properties Associated with Significant Persons. 1989. Updated information on interpreting Criterion B.

Bulletin 33: National Register Information System Manual for State and Federal Users. 1987. Designed for users of the National Register Information System (NRIS), the database of properties listed in, determined eligible for, or pending listing in the National Register.

Bulletin 34: Guidelines for Evaluating and Documenting Historic Aids to Navigation. 1990. Guidance on evaluating the significance and integrity of historic lighthouses, daymarks, and sound signals, as well as preparing National Register and other preservation planning documentation.

Bulletin 35: National Register Casebook: Examples of Documentation. 1988-89. Examples of multiple property case studies, maritime nominations, and concise nominations.

Bulletin 38: Guidelines for Evaluating and Documenting Traditional Cultural Properties. 1990. Guidance in determining whether properties of traditional and religious cultural significance are eligible for inclusion in the National Register.

Bulletin 39: Researching a Historic Property. 1990. Provides basic information on methods of researching an individual building for listing in the National Register.

Technical Guidance

(See preceding Bibliography for sources of information used in text)

Advisory Council on Historic Preservation, *Fire Safety Retrofitting in Historic Buildings* (1989)

Bevil, Marianne, Meredith Fiske, Anne-Leslie Owens, *Painting Historic Buildings: Materials and Techniques—An Annotated Bibliography* (United States Department of the Interior, National Park Service, Preservation Assistance Division, Washington, D.C., 1993)

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Cowden, Adrienne Beaudet, *Historic Concrete, An Annotated Bibliography* (Washington, DC: U.S. Department of the Interior, National Park Service, Preservation Assistance Division, 1993)

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Department of Transportation, *Lighthouse Maintenance Management Manual* (U.S. Coast Guard, COMDTINST M16500.6A, 1993)

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Olgyay, Victor, *Design with Climate: Bioclimatic Approach to Architectural Regionalism* (Princeton, New Jersey: Princeton University Press, 1973)

Principles of Attic Ventilation (Peoria, Illinois: Airvent, Inc., 1996)

Simonson, Kaye Ellen, *Maintaining Historic Buildings, An Annotated Bibliography* (United States Department of the Interior, National Park Service, Preservation Assistance Division, Washington, D.C., 1990)

Stephen, George, *Remodelling Old Houses without Destroying their Character* (New York: Alfred A. Knopf, 1908)

Weaver, Martin E., *Conserving Buildings* (New York: John Wiley and Sons, Inc., 1993)

Window Directory for Historic Buildings (Washington, DC: U.S. Department of the Interior, National Park Service, Cultural Resources, Preservation Assistance, 1992)

National Park Service Technical Guidance

Technical Preservation Services (TPS), Heritage Preservation Services, National Park Service, conducts a variety of activities to guide federal agencies, states, and the general public in planning and undertaking project work on historic buildings, structures, sites, objects, and districts listed in the National Register of Historic Places. In addition to establishing standards and guidelines, the Service develops, publishes, and distributes technical information on responsible approaches to treating significant historic properties.

A listing of the popular *Preservation Briefs* is provided below. Although one copy may be requested free of charge, TPS books, handbooks, technical leaflets and videos are generally available from several sales outlets, including the Superintendent of Documents, Government Printing Office (phone orders: (202) 512-1800); the National Technical Information Service, (703) 487-4600; the Historic Preservation Education Foundation; and a variety of other partnership outlets. A Catalog of Historic Preservation Publications, *Caring for the Past*, with stock numbers, prices, and ordering information may be obtained by contacting: National Park Service, TPS, Heritage Preservation Services Information Desk, P.O. Box 37127, Washington, D.C. 20013-7127. Telephone: (202) 343-9583; FAX (202) 343-3803; e:mail: hps-info@nps.gov

Preservation Briefs

Preservation Briefs assist owners and developers of historic buildings in recognizing and resolving common preservation and repair problems prior to work. The briefs are especially useful to preservation tax incentive program applicants because they recommend those methods and approaches for rehabilitating historic buildings that are consistent with their historic character.

Preservation Briefs 1: The Cleaning and Waterproof Coating of Masonry Buildings. Robert C. Mack, AIA. 1975.

Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings. Robert C. Mack, AIA, de Teel Paterson Tiller, and James S. Askins. Rev., 1980.

Preservation Briefs 3: Conserving Energy in Historic Buildings. Baird M. Smith, AIA. 1978.

Preservation Briefs 4: Roofing for Historic Buildings. Sarah M. Sweetser. 1978.

Preservation Briefs 5: The Preservation of Historic Adobe Buildings. 1978.

Preservation Briefs 6: Dangers of Abrasive Cleaning to Historic Buildings. Anne E. Grimmer. 1979.

Preservation Briefs 7: The Preservation of Historic Glazed Architectural Terra-Cotta. de Teel Patterson Tiller. 1979.

Preservation Briefs 8: Aluminum and Vinyl Siding on Historic Buildings: The Appropriateness of Substitute Materials for Resurfacing Historic Wood Frame Buildings. John H. Myers. Revised by Gary Hume. 1984.

Preservation Briefs 9: The Repair of Historic Wooden Windows. John H. Myers. 1981.

Preservation Briefs 10: Exterior Paint Problems on Historic Woodwork. Kay D. Weeks and David W. Look, AIA. 1982.

Preservation Briefs 11: Rehabilitating Historic Storefronts. H. Ward Jandl. 1982.

Preservation Briefs 12: The Preservation of Historic Pigmented Structural Glass (Vitrolite and Carrara Glass). 1984.

Preservation Briefs 13: The Repair and Thermal Upgrading of Historic Steel Windows. Sharon C. Park, AIA. 1984.

Preservation Briefs 14: New Exterior Additions to Historic Buildings: Preservation Concerns. Kay D. Weeks. 1986.

Preservation Briefs 15: Preservation of Historic Concrete: Problems and General Approaches. William B. Coney, AIA. 1987.

Preservation Briefs 16: The Use of Substitute Materials on Historic Building Exteriors. Sharon C. Park, AIA. 1988.

Preservation Briefs 17: Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character. Lee H. Nelson, FAIA. 1988.

Preservation Briefs 18: Rehabilitating Interiors in Historic Buildings: Identifying Character-Defining Elements. H. Ward Jandl. 1988.

Preservation Briefs 19: The Repair and Replacement of Historic Wooden Shingle Roofs. Sharon C. Park, AIA. 1989.

Preservation Briefs 20: The Preservation of Historic Barns. Michael J. Auer. 1989.

Preservation Briefs 21: Repairing Historic Flat Plaster--Walls and Ceilings. Marylee MacDonald. 1989.

Preservation Briefs 22: The Preservation and Repair of Historic Stucco. Anne E. Grimmer. 1990.

Preservation Briefs 23: Preserving Historic Ornamental Plaster. David Flaharty. 1990.

Preservation Briefs 24: Heating, Ventilating, and Cooling Historic Buildings: Problems and Recommended Approaches. Sharon C. Park, AIA. 1991.

Preservation Briefs 25: The Preservation of Historic Signs. Michael J. Auer. 1991.

Preservation Briefs 26: The Preservation and Repair of Historic Log Buildings. Bruce D. Bomberger. 1991.

Preservation Briefs 27: The Maintenance and Repair of Architectural Cast Iron. John G. Waite; Historical Overview by Margot Gayle. 1991.

Preservation Briefs 28: Painting Historic Interiors. Sara B. Chase. 1992.

Preservation Briefs 29: The Repair, Replacement, and Maintenance of Slate Roofs. Jeffrey S. Levine. 1992.

Preservation Briefs 30: The Preservation and Repair of Historic Clay Tile Roofs. Anne E. Grimmer and Paul K. Williams. 1992.

Preservation Briefs 31: Mothballing Historic Buildings. Sharon C. Park, AIA. 1993.

Preservation Briefs 32: Making Historic Properties Accessible. Thomas C. Jester and Sharon C. Park, AIA. 1993.

Preservation Briefs 33: The Preservation and Repair of Stained and Leaded Glass. Neal A. Vogel and Rolf Achilles. 1993.

Preservation Briefs 34: Applied Decoration for Historic Interiors: Preserving Historic Composition Ornament. Jonathan Thornton and William Adair, FAAR. 1994.

Preservation Briefs 35: Understanding Old Buildings: The Process of Architectural Investigation. Travis C. McDonald, Jr. 1994.

Preservation Briefs 36: Protecting Cultural Landscapes: Planning, Treatment, and Management of Historic Landscapes. Charles A. Birnbaum, ASLA. 1994.

Preservation Briefs 37: Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing. Sharon C. Park, AIA, and Douglas C. Hicks. 1995.

Preservation Briefs 38: Removing Graffiti from Historic Masonry. Martin E. Weaver. 1995.

Preservation Briefs 39: Managing Moisture Problems in Historic Buildings. Sharon C. Park, AIA. 1996.

Preservation Briefs 40: Preserving Historic Ceramic Tile Floors. Kimberly A. Konrad and Anne E. Grimmer. 1996.

Curation

NPS Handbooks, Manuals, and Key Documents

Automated National Catalog System (ANCS) User Manual. April 1987. Developed to computerize accessioning and cataloging, the ANCS has wide-ranging application for both cultural objects and natural history specimens.

Guidance for Meeting NPS Preservation and Protection Standards for Museum Collections. Special Directive 80-1 (Revised), March 1990. This directive outlines the NPS standards for museum collections storage, museum environment, security, fire protection, housekeeping, and museum planning.

Museum Handbook, Part I, Museum Collections. September 1990. Part I provides guidance on scope of collections; environmental monitoring and control; pest management; museum collections storage; handling, packing, and shipping objects; conservation treatment; security and fire protection; emergency planning; curatorial health and safety; planning and programming for museum collections management; and museum ethics. This part of the handbook also addresses preventive conservation for various classes of museum objects.

Museum Handbook, Part II, Museum Records. September 1984. Part II provides guidance on documentation and accountability for cultural collections and natural history collections. The topics addressed include accessioning, cataloging, inventorying, marking, and record photography. An updated Part II (draft in progress) will include guidance on incoming and outgoing loans and deaccessioning.

Museum Handbook, Part III, Use of Museum Collections. Draft in progress. Part III will provide guidance on uses of collections in exhibits, interpretive and educational activities, and research; motion pictures and photography; reproductions; office art; publications; and use of collections by Native American and other ethnic groups.

Tools of the Trade: A Listing of Materials and Equipment for Managing Museum Collections. April 1990. This publication provides a description of and suggested sources for recordkeeping supplies; storage containers; specialty curatorial items, natural history supplies; museum cabinetry, shelving, and shelving racks; and environmental monitoring and control apparatus.

Technical Publications

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NPS Conserve O Gram Series. This series consists of brief, technical leaflets distributed periodically to provide park and museum staff with a wide variety of timely information on specific procedures and techniques for storage, exhibit mounting, and preventive care and maintenance; curatorial health and safety updates; and sources of assistance and supplies. Revision of series (draft in progress) will be available in 1993.

Sheetz, Ron, and Charles Fisher. *Reducing Visible and Ultraviolet Light Damage to Interior Wood Finishes*. Preservation Tech Notes: Museum Collections, No. 2. September 1990.

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American Institute for Conservation of Historic and Artistic Works. *Journal of the American Institute for Conservation* (biannual journal) and *AIC Newsletter* (bimonthly newsletter).

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Case, Mary, ed. *Registrars on Record: Essays on Museum Collections Management*. Washington, DC: American Association of Museums, 1988.

de Torres, Amparo R., ed. *Collections Care: A Selected Bibliography*. Washington, DC: National Institute for the Conservation of Cultural Property, 1990.

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Society for the Preservation of Natural History Collections. *Collection Forum* (biannual journal) and *SPHNC Newsletter* (quarterly newsletter).

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Benson, Susan Porter, Stephen Brier, and Roy Rosenzweig, eds., *Presenting the Past: Essays on History and the Public* (Philadelphia: Temple University Press, 1986)

Blatti, Jo, ed., *Past Meets Present: Essays about Historic Interpretation and Public Audiences.* Washington, D.C.: Smithsonian Institution Press, 1987.

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Technical Brief 3. *Archeology in the National Historic Landmarks Program* by Robert S. Grumet, Mid-Atlantic Regional Office, National Park Service, 1988.

Technical Brief 4. *Archeology in the Classroom: A Case Study from Arizona* by A. E. Rogge and Patti Bell, Arizona Archaeological Council, Archaeology for the Schools Committee, 1989.

Technical Brief 5. *International Site Burial: A Technique to Protect Against Natural or Mechanical Loss* by Robert M. Thorne, Center for Archaeological Research, University of Mississippi, 1989.

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Technical Brief 7. *Federal Archeological Contracting: Utilizing the Competitive Procurement Process* by John H. Jameson, Jr., John E. Ehrenhard, and Wilfred M. Husted, Interagency Archeological Service Division, Southeast Regional Office, National Park Service, 1990.

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Hart, David M., AIA, *X-Ray Examination of Historic Structures* (1975) Available from NTIS, Order Number: PB85-180800)

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National Archives Historical Resources[3]

All of the records described below are unclassified and available for research use. First a researcher's card, available at no cost, must be obtained at the National Archives or any Archive Branch. Archivists and findings aids are available to assist you in your research. Most records must be "pulled" from the stacks and delivered to you in reading rooms. Records are usually not pulled upon demand but by predetermined schedules—you may have to wait until the next scheduled pull before you receive the records you requested. There are typically four pulls per day. Before you enter the reading room all personal belongings such as brief cases, purses, pens, etc., must be placed in lockers operated by a refundable quarter; however, laptops are generally permitted. Paper and pencils are provided. Research notes are allowed only after inspection and are stamped. These and other strict requirements are necessary in order to ensure that documents are not harmed or stolen. Debit cards can also be bought to be used in copying machines.

Many of the U.S. lighthouses records are in the National Archives, Record Group 26. These records, dating from 1789 onward, consist of ledgers, correspondence, journals, log books, contracts, plans, plats, and other textural records. These records are not complete because of failure of agencies to deposit records as required and a fire at the Commerce Department in 1921. Some of the destroyed records were partially replaced by "field records" kept at Coast Guard District Headquarters. An inventory of Record Group 26 was prepared in 1963 and in the following year "field records" brought to the National Archives were also inventoried. Inspection reports, containing information on building conditions, etc., for lighthouse stations are sometimes available from Districts.

The primary tenet of arranging archival records is based on "provenance." Because the government entity responsible for overseeing lighthouses has undergone eleven incarnations since its establishment in 1789, and because records from each agency are kept separate and not intermixed, lighthouse archival information is located in several different record groups, and at several different locations within the National Archives. Additionally, some specific activities of lighthouse related activities, such as land purchasing, budget preparation, territorial lighthouse governance, and the nomination of lighthouse employees, often involved outside agencies whose primary functions were unrelated to lighthouse work. For example, beginning in 1831, the Army Corps of Engineers assisted the Lighthouse Establishment in the design and construction of lighthouse buildings, light vessels, and buoys. The correspondence files of the Office of the Chief Engineer, 1789 to 1923, include a large number of letters relating to lighthouse construction, repairs, inspections, and conditions of lighthouses. Many contracts for lighthouse buildings are included in the records of the General Accounting Office. Therefore, there are many places to search for lighthouse-related records. A through research of lighthouses will require perseverance, creative thinking, and familiarity with the administrative history of the agencies which governed lighthouses throughout their existence.

The Congressional Serial Set of government reports such as *American State Papers* include primary information on lighthouses and are available at many larger libraries throughout the United States. The annual reports of the Coast Survey often contain information on the selection of lighthouse sites. The annual reports of the Secretary of War sometime contain information on army officers on detached duty with the lighthouse service. During times of war this was very common. During the American Civil War, a Confederate Lighthouse Bureau was established under the Confederate Treasury Department. These records contain information on southern lighthouses from 1860 to 1865. The *Annual Reports* of the Lighthouse Board, beginning in 1852, contain information such as requests by the Board to Congress for appropriations to build, repair and improve lighthouses.

The National Archives has "Clipping Files" from 1855 to 1932 for most lighthouses. The files are arranged by District and thereafter alphabetically by lighthouse. The entry from each (or nearly each) annual report has been cut out and compiled (clipped) together to give a summary history of what was published in lighthouse agencies annual reports. It is suggested you double check the actual series as some entries are often missing, especially for the later years. This aid is very useful

[3] Taken largely from Elizabeth K. Lockwood, "Searching for the Light: Textural Record[s] Relating to Lighthouses in the National Archives" (April 25, 1990).

in tracing repairs and alterations to buildings, and construction of new buildings over time.

Descriptive Lists of Lighthouses, 1858 to 1938, give the most detailed physical information. Arranged by District, information often includes building materials and dimensions of structures, size and type of illuminating apparatus, lanterns, lamps, and fog signals.

Another useful aid is "Form 60," a series of nearly 200 questions regarding the physical characteristics, healthfulness, quality of drinking water, etc. for each station. These forms were send to all keepers around the turn of the century. Most keepers answered the majority of the questions. These forms are arranged alphabetically by State, and thereafter by lighthouse.

The National Archives also maintains a *Lighthouse Site Files*, 1790 to 1939. Arranged alphabetically by State, and thereafter by lighthouse, each file contains legal descriptions of lighthouse land sites, land ownership changes through time, and often land surveys, plats, site plans, letters, contracts, and other miscellaneous information. Light Station Log Books provide the most detailed information on day to day life at a lighthouse, as the keepers were required to keep a log recording notable events, extreme weather conditions, personnel issues, repairs, visitors, delivery of supplies, and the comings and going of keepers. Some keepers were more descriptive than others, so usefulness of information varies.

The U.S. Lighthouse Board, *Documents Relating to Lighthouses*, 1789-1871 is especially useful for pre-1852 built lighthouses. Another useful serial is *Light List*, which gives a yearly update on light characteristics of lighthouses and lightships. The first *Light List* was published in 1838, but annual publication did not begin until 1910 with the establishment of the Bureau of Lighthouses. The *American Coast Pilot*, first published in 1796 and revised periodically up until 1867 also gives good descriptions of lighthouses, often accompanied with shoreline sketches showing the lighthouse and surrounding topography. Administrative records of the Coast Guard after 1950 remain in the custody of the Department of Transportation.

The *Official Register of the United States*, published in odd-numbered years, from 1829 until 1919, lists employees of the central office of the Lighthouse Establishment, as well as, employees "at large," including district inspectors and engineers, lighthouse keepers, assistant keepers, vessel crews, etc. The register includes the employees name, duty location, place of birth, date of appointment, and salary. Beginning in 1921 the register includes only administrative personnel. The most complete information on lighthouse keepers, is the "Register of Lighthouse Keepers, 1845-1912" (microfilm publication number M1373), which consists of 19 volumes of registers microfilmed in geographic order by five regions: New England; New York through Virginia; North Carolina through Texas; Great Lakes; and West Coast, Alaska, and Hawaii. Each microfilm roll has an alphabetical index by keeper sir name and/or name of lighthouse. These registers provide information regarding dates of appointments and salary information. With this information other fragmentary personnel records can be consulted including correspondence regarding appointments and dismissals, records of district inspectors and engineers, records of delinquencies, and retirement cards.

Photographs and plans are available from the College Park, Maryland, branch of the National Archives, referred to as "Archives II." Some lighthouse plans as well as other information are housed at the National Archives Regional Offices. For information on plans see "Lighthouse Plans in the National Archives: A Special List of Lighthouse-related Drawings in Record Group 26."[4]

Outline of Records in the National Archives Relating to Lighthouses

Record Group 26: Records of the United States Coast Guard

Finding Aid: Forrest Holdcamper, "Preliminary Inventory of the Records of the United States Coast Guard," an unpublished finding aid in the National Archives.

A. Records of the Lighthouse Service, 1790-1950

1. General Records: journals and meeting minutes of the Light-House Board; annual reports; correspondence between chairs of committees and the Light-House Board; circulars of the Light-House Service; bulletins of the Light-House Bureau; newspaper clippings concerning activities of the Board; correspondence to and from the Light-House Service, Board, and Bureau, including letters to and from district officials; and indexes

[4] William J. Heynen, Elizabeth K. Lockwood, and Margo Szabunia, Special List 57, National Archives and Records Administration (Washington, D.C. 1990).

and registers to incoming and outgoing correspondence.

2. Records Relating to Legal Matters: reports concerning lighthouse personnel, and records relating to legal claims.

3. Records Relating to Operations: Light-House Service publications descriptions of lighthouses; abstracts of titles to sites; site files; journals and reports of lighthouses; reports of physical condition of lighthouses; reports of inspections of lighthouses; reports relating to repairs; lighthouse plans and specifications; drawings of illuminating apparatus; reports of shipwrecks near lighthouses; and lighthouse logs.

4. Personnel and Payroll Records: correspondence concerning keeper and assistants; correspondence concerning personnel of lighthouse vessels; nominations for and ratings of employees of Light-House Board; personnel records of engineers and inspectors; records of engineers and crews of lighthouse vessels; notices of removal; list of appointments and transfers; record of salary of lighthouse keepers; personnel charts; and retirement record cards.

5. Field Records.

a. The records housed in the main National Archives Building include: correspondence, primarily between the Lighthouse Service and the district engineers and district superintendent from the 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, and 12th lighthouse districts. Finding aid: Forrest Holdcamper, "Preliminary Inventory of the Field Records of the Light-House Service," an unpublished finding aid in the National Archives.

b. Records in the New England Region of the National Archives include: general records; records relating to the construction, repair, and alternations of lighthouses; reports of lighthouses; and correspondence relating to lighthouses.

c. Records in the Mid-Atlantic, Great Lakes, Southwest, Pacific Southwest, and Pacific Sierra Regional Branches include some lighthouse log books.

B. General Records of the U.S. Coast Guard

1. Textual records maintained by the central office of the U.S. Coast Guard include: logs of vessels, stations, or depots; and records relating to the transfer of the Bureau of Marine Inspection and Navigation and the Lighthouse Service to the Coast Guard.

2. Audiovisual records maintained by the central office of the U.S. Coast Guard include: prints and negatives of lighthouses; oversized prints and artworks of lighthouses; negatives and prints of survey of lighthouses; photographs of light tenders; stock film and newsreels of Coast Guard activities relating to lighthouses; and plans and drawings of lighthouses. Finding aids are available in the National Archives Still Pictures Branch, the Cartographic and Architectural Drawings Branch, and the Motion Picture, Sound, and Video Branch.

Record Group 40: Records of the Department of Commerce

The general correspondence files of the Secretary of Commerce, 1903 to 1950 are arranged numerically, and indexed in five-year increments by alphabetically arranged index cards. Indexes include names of individual lighthouses, in addition to entries under Light-House Board, Light-House Service, and Light Vessels. Finding aid: Forrest Holdcamper, "Preliminary Inventory of the General Records of the Department of Commerce," a listed finding aid in the National Archives.

Record Group 49: Records of the Bureau of Land Management

Records of Division K of the Bureau include registers of lighthouse reservations; and records relating to non-military (1860-1940) and abandoned military (1822-1937) reservations, which include information relating to lighthouse lands. Finding aid: "The General Land Office: Administrative Records of the General Land Office, 1785-1955," an unpublished finding aid in the National Archives.

Record Group 55: Records of the Government of the Virgin Islands

The general files are arranged by subject-classification numbers in periods, 1917-1927 and 1934-1943. In the first period, "79" is the classification number for lighthouses and the Lighthouse Service; the classification in the second period is "52." Finding aid: J. Donn Hooker, "Records of the Government of the Virgin Islands of the United States," finding aid in the National Archives.

Record Group 77: Records of the Office of the Chief of Engineers

The connection of engineer officers with the construction of lighthouses dates from 1831 when the Treasury Department allocated money approved for lights on lakes to the Army Corps of Engineers for disbursement. Several series of correspondence of the Chief of Engineers from 1831 to 1923 contain information relating to lighthouse construction, land, condition of lighthouses, repairs, and inspections. Two main subject indexes provide access to these numerically-arranged records. Finding aid: Elizabeth Bethel and Maizie H. Johnson, "Preliminary Inventory of the Textual Records of the Office of the Chief of Engineers," an unpublished finding aid in the National Archives.

Record Group 217: Records of the Accounting Officers of the Department of the Treasury

Finding aid: William F. Sherman, "Inventory of the Records of the Accounting Officers of the Department of the Treasury," an inventory in the National Archives.

A. Records of the Register of the Treasury include: daybooks from 1789 to 1894; general Customs ledgers from 1849 to 1908; Customs journals from 1849 to 1896; and ledgers of lighthouse engineers and inspectors under the Department of Commerce and Labor from 1903 to 1909.

B. Records of the Office of the First Comptroller include: miscellaneous letters sent to Customs offices relating to their activities as superintendents and disbursing offices for lighthouses; contracts for the construction and repair of lighthouses from 1800 to 1903; and contracts for the construction and supplies for the Bureau of Lighthouse under the Department of Commerce, 1919-1923.

C. Records of the Office of the Commissioner of Customs include accounts; construction accounts; correspondence; and oaths of office of lighthouse keepers.

D. Records of the Office of the First Auditor include: correspondence sent to collectors and other Customs officers concerning settlement of their accounts for Customs receipts and expenditures and for disbursement accounts for lighthouses; audit reports; and settled accounts.

Record Group 365: Records of the Treasury Department Collection of Confederate Records

Finding aid: Carmelita Ryan, "Treasury Department Collection of Confederate Records," a finding aid in the National Archives.

During the Civil War, the confederate States of America established a Government structure paralleling the Union Government, which included a Confederate Treasury Department and a subordinate Lighthouse Bureau. The Treasury Department Collection of Confederate records includes: correspondence of the Lighthouse Bureau from 1861 to 1864; and records relating to Southern lighthouses from 1860 to 1865.

Summary of Historic and Cultural Preservation Laws, Regulations, Orders, and Procedures

For a more complete review and discussion of many of these laws refer to "Introduction to Federal Projects and Historic Preservation Law, Participants's Desk Reference: Legislation, regulations, guidelines, and related information about historic preservation policies and requirements under the National Historic Preservation Act of 1966," issued January 1995 by the Advisory Council on Historic Preservation and The GSA Interagency Training Center.

Laws

Advisory Council on Historic Preservation, Protection of Historic Properties—Advisory Council on Historic Preservation (ACHP), Protection of Historic Properties, 36 C.F.R. Part 800 (1979) is the result of President Carter requesting the Council issue its procedures in the form of binding regulation. These procedures where first issued in 1973 as non-binding procedures to implement the Section 106 review process. Published in the Code of Federal Regulations as 36 C.F.R. Part 800, they were soon interpreted by the courts as the standards against which Section 106 compliance must be measured. This was reinforced when reissued as a true regulation in 1979.

American Folklife Preservation Act—The American Folklife Preservation Act (AFPA) of 1974 expressed Congressional support for the documentation, and enhancement and celebration of folklife, and established national policy to document and enhance folk culture.

American Indian Religious Freedom Act—American Indian Religious Freedom Act (AIRFA) of 1978 (P.L. 95-341, Stat. 469; 42 U.S.C.§ 1996) established U.S. policy to "protect and preserve for American Indians, Eskimos, Aleuts, and native Hawaiians their inherent right of freedom to believe, express, and exercise [their] traditional religions... including but not limited to access to sites..." The courts have interpreted AIRFA to require Federal agencies to consult with tribes about effects of their actions on the exercise of traditional religions. Many traditional religious sites are historic properties, but AIRFA goes beyond historic preservation, requiring attention to religious practices as well as places. Rights include: accessing sites; using and keeping sacred objects; celebrating traditional rites; and consulting tribal leadership concerning tribal human burial sites which agency projects might disturb.

Americans with Disabilities Act—The Americans with Disabilities Act of 1990 extends comprehensive civil rights to individuals with disabilities including elimination of barriers in new facilities and alteration of existing facilities (including historic buildings, sites and landscapes). Provisions include alteration requirements for buildings and facilities that cannot be made physically accessible without threatening or destroying their significance. For more information on this subject see "Preserving the Past and Making it Accessible for People with Disabilities," October 1992, National Park Service.

Antiquities Act—The Antiquities Act of 1906 (P.L. 59-209, 39 Stat, 335; 16 U.S.C.§§ 431-433) authorizes the President to designate as National Monuments historic and natural resources of national significance located on federally owned or controlled lands. The act further provides for the protection of all historic and prehistoric ruins and objects of antiquity located on Federal lands by providing criminal sanctions against excavation, injury, or destruction of such resources.

Archaeological and Historic Preservation Act—Archaeological and Historic Preservation Act (AHPA) of 1974 (P.L. 93-291m 88 Stat. 174; 16 U.S.C. §§ 469-469c) directs Federal agencies to report to the Secretary of the Interior when their actions may damage archeological sites, and to conduct or assist in the recovery of data from such sites. AHPA authorizes transfer of up to 1% of project funds to the Department of the Interior to help cover costs of such recovery.

Archeological Resources Protection Act—The Archeological Resources Protection Act (ARPA) of 1979 (P.L. 96-95, 93 Stat. 712; 16 U.S.C.470 aa-11) prohibits the disturbance of archeological sites on Federal and Indian land without a permit from the responsible land manager. The Act authorizes agency permit procedures for investigations of archeological resources on public lands under the agency's control, and prescribes substantial criminal and civil penalties for any violation. Only scientific and educational institutions may obtain permits and then only if the excavated material is used to increase knowledge about archeological resources. The Act also makes it a crime for the removal, sale, receipt, and interstate transportation of archeological resources obtained illegally (without permits) from public or Native American lands. Penalties for a criminal first offense is a $10,000 fine, one year in jail, or both, however if the cost of restoration or repair of the resource exceeds $500 the fine is $20,000, two years in jail, or both. Subsequent criminal offenses my bring fines up to $100,000, 5 years in jail, or both. Civil fines are based on the archeological or commercial value of the resource and cost of restoration and repair. Penalty also includes forfeiture of all archeological resources, vehicles, and equipment. Archeological resource exceptions are projectile points (arrowheads) found on the surface of the ground, coins, bullets, unworked minerals and rocks, and paleontological remains. See Glossary for definition of Archeological Resource.

Architectural Barriers Act—The Architectural Barriers Act (P.L. 90-480; 42 U.S.C.§§ 4151-4157) establishes procedures and sets up a an Architectural and Transportation Barriers Compliance Board which insure that alteration of existing federal building or the construction of new federal buildings take into consideration physically handicapped persons. There are special exceptions for alteration of "historical, architectural, or cultural significance" buildings including, but not limited to, buildings listed or eligible to be listed on the National Register.

Curation of Federally Owned and Administered Archeological Collections—see 36 CFR 79 below.

Department of Transportation Act—The Department of Transportation Act of 1966 (P.L. 89-670, 80 Stat. 931; Section 4(f) 49 U.S.C.§303) specifies that the Secretary of Transportation may approve any program or project that requires the use of land from a historic site of national, State, or local significance, as determined by Federal, State, or local officials having jurisdiction thereof, only if (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such historic property. The term *"historic site" in not limited to resources listed in or eligible for the National Register, it must also include locally significant properties which, for one reason or another, might not meet the National Register criteria*. This act applies to the Federal Highway Administration, Federal Aviation Administration, the Urban Mass Transportation Administration, and the U.S. Coast Guard.

Executive Order No. 11593, *Protection and Enhancement of the Cultural Environment*—Executive Order No. 11593, May 13, 1971, Protection and Enhancement of the Cultural Environment (36 Fed. Reg. 8921, reprinted in 16 U.S.C.§ 470 note) was issued by President Nixon. It elaborated on Federal agency responsibilities under NHPA and NEPA and included direction for agencies to identify historic properties under their jurisdiction or control, extended Section 106 review to effects on "eligible" properties, and gave the Advisory Council on Historic Preservation independent agency status. Many of these responsibilities were folded into NHPA by amendment in 1980.

Federal Property and Administrative Services Act—The Federal Property and Administrative Services Act of 1949 as amended in 1972 (40 U.S.C.§ 484(k)(3)) authorizes the General Services Administration to convey approved surplus Federal property to any State agency or municipality free of charge, provided that the property is used as a historic monument for the benefit of the public. The act is also applicable to revenue-producing properties if the income in excess of rehabilitation or maintenance cost is used for public historic preservation, park, or recreation purposes and the proposed income-producing use of the structure is compatible with historic monument purposes, as approved by the Secretary of the Interior. The act includes provisions under which the property would revert to the Federal Government should it be used for purposes incompatible with the objective of preserving historic monuments.

Federal Records Act—Federal Records Act (FRA) (16 U.S.C. Chapters 21, 25, 27, 29, 31, 33) requires agencies to preserve Federal records of potential historical value, which may include the administrative records of a Coast Guard installation, following procedures promulgated by the National Archives and Records Administration. These procedures include:

Authorizing Federal agencies to retain records beyond congressional-approved disposal schedules. Withdraws disposal authorizations covering records listed in congressional disposal schedules. This requirement needs to be kept in mind during implementation of an adaptive re-use, realignment, and decommissioning plans, during which there is a high potential for discarding of records. Destruction or removal of Federal records may result in a violation of FRA and carries a fine of $2,000 or three years in jail, or both (18 U.S.C. 2071).

General Authorities Act—The General Authorities Act of 1979 (P.L. 94-458. Stat. 1939) authorizes the secretary of the Interior "to withhold from disclosure to the public, information relating to the location of sites or objects listed on the National Register whenever he determines that disclosure of specific information would create a risk of destruction or harm to such sites or objects.

Historic Sites Act—The Historic Sites Act (HSA) of 1935 (P.L. 74-292, 49 Stat. 666; 16 U.S.C.§§ 461-467) established as national policy "to preserve for public use historic sites, buildings and objects of national significance for the inspiration and benefit of the people of the United States." The Act authorizes and directs the Secretary of the Interior to make a "survey of historic and archeological sites, buildings, and objects for the purpose of determining which possess exceptional value as commemorating or illustrating the history of the United States." This program has become known as the National Historic Landmark Program and properties so designated are referred to as National Historic Landmarks (NHLs). NHLs are usually designated as part of "theme studies" such as War in the Pacific, Man in Space, and a current theme study on American Lighthouses. NHLs are automatically listed on the National Register. Establishes a maximum fine of $500 for violation of the Act.

Unlike National Register properties, the Coast Guard is not mandated to inventory and recommend NHL properties. However, **Section 110(f)** of NHPA requires that prior to the approval of any Federal undertaking which may directly and adversely affect any National Historic Landmark, the head of the responsible Federal agency shall, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to such landmark, and shall afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on the undertaking.

36 CFR § 800.10 of the Advisory Council's Section 106 regulations specify how agencies are to comply with Section 110(f) of NHPA. Essentially it is the same for any other consultation under Section 106 except that:

- the Council must be included in any consultation regarding the resolution of adverse effect on an NHL;
- the Council may ask the Secretary of the Interior to provide a report about the significance of the property, the effects of the undertaking, and what might be done to mitigate such effects; and
- the Council reports its comments to the President, Congress, and the Secretary of the Interior, as well as to the agency head.

National Archives and Records Administration— National Archives and Records Administration (NARA), Disposition of Federal Records law of 1984 (36 C.F.R. Part 1228) came about when NARA became an independent agency and through which official agency records must be appraised through agency record schedule procedures administered by the agency records officer. See Appendix 1 for definition of Federal Records. NARA's *Disposition of Federal Records* (1992) is a manual which fully covers this issue. It is available from National Archives and Records Administration, Office of Records Administration, Washington, D.C.

National Environmental Policy Act—The National Environmental Policy Act of 1969 (NEPA)(P.L. 91-190, 31 Stat. 852; 42 U.S.C.§§ 4321-4370) created a new context in which the management of all kinds of cultural resources could be addressed. It was only after NEPA's passage that Federal agencies began to address community lifeway resources in any explicit way, and NEPA remains the primary legal authority for considering such resources. NEPA also caused agencies to develop the infrastructure of the positions, offices, regulations, and guidelines needed to manage other kinds of cultural resources, notably historic real property. The Council on Environmental Quality (40 CFR 1500-08) regulate the policy. The Council encourages combining NEPA documents and procedures with other necessary agency documentation (40 CFR 1506.4).

Federal Agency Responsibilities—"Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;" "preserve important historic, cultural, and natural aspects of our national heritage;" and agencies are directed to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and *social sciences* and the environmental design arts in planning and in decision making . . ."

National Historic Preservation Act of 1966—The National Historic Preservation Act of 1966 (NHPA), as amended in 1980 (P.L. 89-655, 80 Stat. 915; as amended by P.L. 91-243, 84 Stat. 204; P.L. 93-54; P.L. 94-422, 90 Stat. 1313; P.L. 94-458; P.L. 96-199; P.L. 96-244; P.L. 96-515, 94 Stat. 2987; P.L. 98-483; P. L. 99-514; P.L. 100-127, 106 Stat. 4753; 16 U.S.C. 470) is the nation's central historic preservation law. The Act sets forth policy of the U.S. Government regarding historic preservation and promotes conditions in which historic properties can be preserved in harmony with modern society, and fulfill society's needs.

Federal Agency Responsibilities—The Act directs Federal agencies to name "Agency Preservation Officers" to coordinate their historic preservation activities, to seek ways to carry out their activities in accordance with the purposes of the Act, to identify historic properties under their jurisdiction, to consider such properties when planning actions might affect them, to give the Advisory Council an opportunity to comment on such actions, and to document historic properties that cannot be saved. The "Agency Preservation Officer" for the Coast Guard is located at the Department of Transportation Headquarters, Washington, D.C. The Act also established the National Register of Historic Places and the State Historic Preservation Officers, which are described below.

The 1980 amendments included the addition of Section of 110, which articulated broad, affirmative responsibilities in historic preservation for Federal agencies. These amendments also directed the National Park Service to issue regulations governing how Federal agencies would manage, or "curate," their collections of artifacts recovered from archaeological excavations. These regulations, *36 CFR Part 79*, were published in 1990. They provide the basic standards that Federal agencies must meet in managing their artifact collections. In addition, the amendments specified State Historic Preservation Officer (SHPO) responsibilities and established a special program for participation by local governments. 36 CFR Part 800 was revised and reissued in 1986.

NHPA was amended again in 1992. This amendment strengthened Section 106 review and increased, among several items, the historic preservation responsibilities of Federal agencies including:

- require Federal agencies to have preservation programs with specially defined elements;
- require Federal agencies to have Section 106 procedures meeting specific standard; and
- discourage "anticipatory demolition" of historic properties.

Native American Grave Protection and Repatriation Act—The Native American Grave Protection and Repatriation Act (NAGPRA) of 1987 (P.L. 101-601, 104 Stat. 3049; 43 U.S.C. 2101 *et seq.*) prohibits the intentional removal of Native American cultural items from Federal or tribal lands, except under an ARPA permit and in consultation with the appropriate Native American groups. The Act requires Federal agencies and museums to inventory their holdings of "Native American culture items" and return of such items including human remains, associated funerary objects, sacred objects, and objects of cultural patrimony to the appropriate Indian tribes and other Native American groups. It establishes Native American ownership of human remains and associated artifacts discovered on Federal lands after the date of enactment. It also provides for a minimum 30-day delay when a project on Federal or Indian land encounters such an item.

In 1988, a Supreme Court ruling *Lyng, Secretary of Agriculture v. Northwest Indian Cemetery Protective Association* seriously undercut the power of Indian tribes to protect their religious sites and practices using AIRFA. A new, beefed-up law now called the Native American Free Exercise of Religion Act (NAFERA), is under consideration by Congress. The form and content of NAFERA is being negotiated, and remain to be fully defined.

Public Buildings Cooperative Use Act—The Public Buildings Cooperative Use Act of 1976 (P.L. 94-541; Stat. 2505) requires the General Services Administration to acquire space for federal agencies in buildings of architectural or cultural significance where feasible; and amended the Architectural Barriers Act of August 12, 1968, relating to the accessibility of certain buildings to the physically handicapped.

Theft of Government Property—Section 641, Public money, property or records (18 U.S.C. 641) states whoever embezzles, steals, purloins, or knowingly converts to his use or the use of another, or without authority, sells, conveys or disposes of any record, voucher, money, or thing of value of the United States or of any department or agency thereof, or any property made or being made under contract for the United States or any department or agency thereof; or whoever receives, conceals or retains the same with intent to convert it to his use or gain, knowing it to have been embezzled, stolen, purloined or converted shall be fined not more than $10,000 or imprisoned not more than ten years, or both; but if the value of such property does not exceed the sum of $100, he shall be fined not more than $1,000 or imprisoned not more than one year, or both. Archeological objects, historical records, and pieces of historic buildings taken from federal lands and structures constitute theft of government property.

World Heritage Convention—The World Heritage Convention of 1980 (P.L. 96-515, Stat. 3000) under Title IV of the NHPA Amendments directs the secretary of the Interior to nominate properties of international significance to the World Heritage List; and requires federal agencies to consider the effects of their undertakings on properties outside of the United States on the World Heritage List or on the applicable countries' equivalent of the National Register. Presently the Coast Guard has no known properties on the World Heritage List or no known properties outside of the United States on applicable countries' National Register equivalent. However, the Coast Guard operates facilities in Argentina, Norway, Liberia, La Reunion Island (France), Japan, and Australia.

Regulations

Regulations are promulgated and published in the *Code of Federal Regulations* (CFR) to direct the implementation of laws. The following CFR citations are most pertinent to cultural resource management.

32 CFR 229, "Archeological Resources Protection Act of 1979; Final Uniform Regulations."

36 CFR 18 (National Historic Preservation Act of 1966), "Leases and Exchanges of Historic Property," governs the historic property leasing and exchange provisions of this law.

36 CFR 60 (NHPA and EO 11593), "National Register of Historic Places," addresses concurrent state and federal nominations, nominations by federal agencies, revision of nominations, and removal of properties from the National Register.

36 CFR 61 (NHPA and EO 11593), "Procedures for Approved State and Local Government Historic Preservation Programs," establishes standards for the approval of state historic preservation programs; requires state historic preservation officers to conduct statewide surveys of cultural properties, prepare and implement state preservation plans, and cooperate with federal agencies in Section 106 compliance; sets qualification standards for preservation professionals.

36 CFR 63 (NHPA and EO 11593), "Determinations of Eligibility for inclusion in the National Register of Historic Places," establishes process for federal agencies to obtain determinations of eligibility on properties.

36 CFR 65 (Historic Sites Act of 1935), "National Historic Landmarks Program," establishes criteria and procedures for identifying properties of national significance, designating them as national historic landmarks, revising landmark boundaries, and removing landmark designations.

36 CFR 66 "Recovery of Scientific, Prehistoric, Historic and Archeological Data."

36 CFR 68 (NHPA) contains the secretary of the interior's standards for historic preservation projects, including acquisition, protection, stabilization, preservation, rehabilitation, restoration, and reconstruction.

36 CFR 78 (NHPA), waiver of Federal Agency Responsibilities Under Section 110 of the National Historic Preservation Act.

36 CFR 79 (NHPA and ARPA), "Curation of Federally Owned and Administered Archeological Collections," provides standards, procedures and guidelines to be followed by Federal agencies in preserving and providing adequate long-term curatorial services for archeological collections of prehistoric and historic artifacts and associated records that are recovered under Section 110 of the NHPA, the Reservoir Salvage Act, ARPA and the Antiquities Act. The National Park Service has published a "reader-friendly" version of this regulation under the same title (1991).

36 CFR 800 (NHPA and EO 11593), "Protection of Historic and Cultural Properties," includes regulations of the Advisory Council on Historic Preservation to implement Section 106 of the National Historic Preservation Act as amended and presidential directives issued pursuant thereto.

36 CFR 1222-1238 (Federal Records Act), "Records Management"

43 CFR 3 (Antiquities Act) establishes procedures to be followed for permitting the excavation or collection of prehistoric and historic objects on federal lands.

43 CFR 7, Subparts A and B (Archaeological Resources Protection Act, as amended), "Protection of Archeological Resources, Uniform Regulations" and "Department of the Interior Supplemental Regulations," provides definitions, standards, and procedures for federal land managers to protect archeological resources and provides further guidance for Interior bureaus on definitions, permitting procedures, and civil penalty hearings.

43 CFR 10 (Native American Graves Protection and Repatriation Act)

Directives

Department of Transportation Order 5610.1C, *Procedures for Considering Environmental Impacts*—Section 2.E.1.a. on historical properties responsibilities states the Coast Guard: "(1) has the final responsibility in accordance with 36 CFR 800.4(a) to identify historical and cultural resources in the vicinity of a proposed project. These resources include districts, sites, building, structures, and objects significant in American history, architecture, archeology, or culture." (2) All Coast Guard actions require compliance with section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Part 470, *et seq.*), as amended; Executive Order 11593, Protection and Enhancement of the Cultural Environment; 40 CFR Section 1502.25(a); 36 CFR Part 800 (Protection of Historic and Cultural Properties) which implements Section 106 of the National Historic Preservation Act and Executive Order 11593; 36 CFR Parts 60 and 63; and any other appropriate implementing regulations. (3) In order to comply with the above, the responsible Coast Gaud official shall review the National Register of Historic Places (NRHP), and its supplements, to determine if any Coast Guard actions will effect properties listed or proposed for listing. In addition, the Cost Guard official is responsible for investigating the project area to determine if any resources meet the criteria for evaluation given in 36 CFR Section 60.4 (In brief, 36 CFR Section 60.4 states that properties of historical, architectural, or archaeological significance should be considered for national Register evaluation if they are associated with events and persons significant in our past, or that have distinctive character, artistic values or the work of a master, or have yielded or are likely to yield important information in pre-history or history. 36 CFR Section 60.4 provides specific criteria and should be referenced.) (4) The responsible official shall coordinate with the State Historic Preservation Officer and the Department of the Interior (National Register) to determine eligibility or the need to nominate the property, if owned by the Coast Guard. (5) The responsible Coast Guard official shall document all investigations concerning historic and cultural properties. If no properties are found, or if properties are found near the project area, it should be so documented and supported in the case file."

Section 2.E.1.b. on Advisory Council on Historical Preservation states "(1) The responsible Coast Guard official shall forward adequate documentation of a finding of no adverse effect to the Executive Director of the Advisory Council on Historic Preservation in accordance with 36 CFR Section 800.4(c). (2) For Coast Guard actions where it is determined that there is an adverse effect on the protected property, the responsible Coast Guard official shall prepare the Preliminary Case Report (36 CFR Section 800.13(b)) and submit it to the Advisory Council for Historic Preservation in accordance with 36 CFR Section 800.4(d). When the Memorandum of Agreement (MOA) is prepared (36 CFR Section 800.6(c)), the Coast Guard official responsible for final agency action (issuance or detail of the permit) shall sign for the Coast Guard.

Section 2.E.1.c. on Public and Agency Involvement states, "The District Commander shall send a copy of the public notice to the State Historic Preservation Officer (SHPO), the National Park Service and other known agencies having expertise with regard to possible historic resources. In addition, individuals or groups having special interest or expertise, such as county or city historical preservation groups, should receive the public notice."

COMDTINST M16475.1B, *National Environmental Policy Act*—establishes policy and prescribes responsibilities and procedures for Coast Guard implementation of NEPA Environmental Impact Statements. Appropriate sections on historical and cultural resources are included.

COMDTINST M4500.5, *Property Management Manual*—requires that all artifacts owned by the Coast Guard are to be recorded, and identified as, in the *Personal Property Accountability* (PPA) System along with the value of each item. The

Public Affairs Manual assigns the History Branch responsibility to maintain "... a service wide inventory of ... artifacts, ensuing that they are identified, appraised and recorded into the ... PPA System."

COMDTINST M5212.12, *Paperwork Management Manual*—prescribes policies and outlines procedures for administering the Coast Guard paperwork management program as it relates to the management of records, filing systems, reports, and forms.

Special Directive 82-12, *Historic Property Leases and Exchanges*—elaborates on the leasing and exchange of historic properties under Section 111 of the National Historic Preservation Act of 1966 as amended.