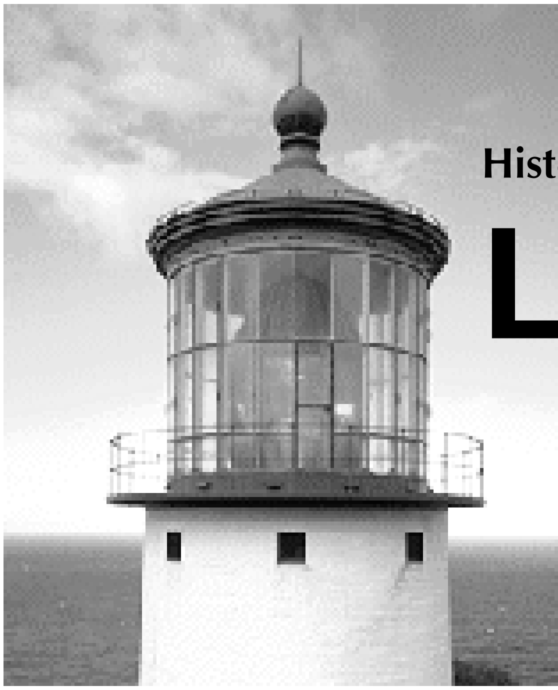
Historic Lighthouse Preservation:

LANTERN

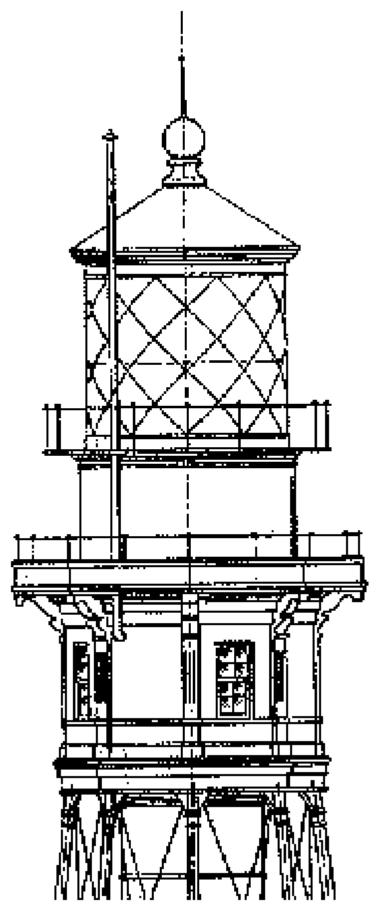


NMI photo

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.

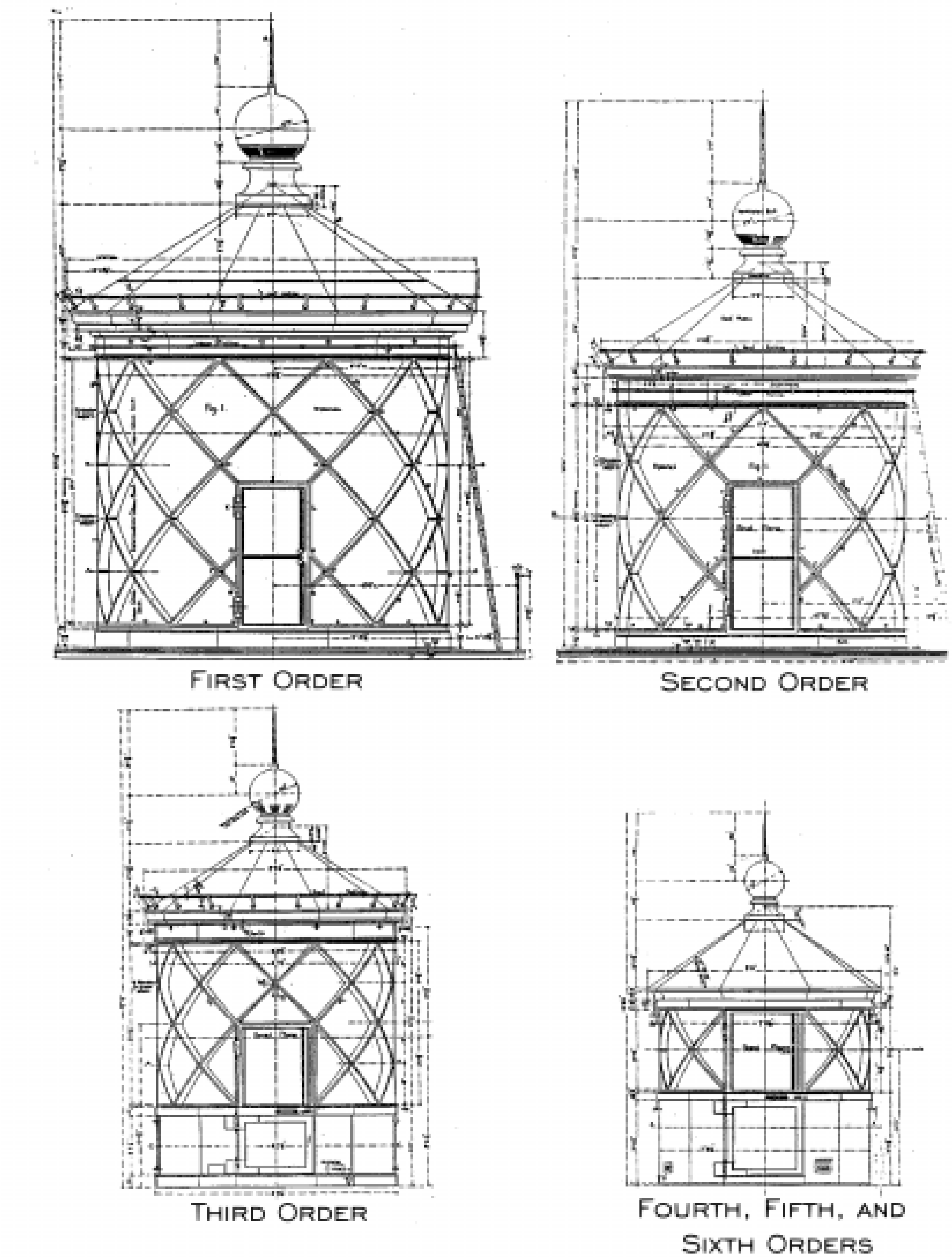


Figure 3. Illustration of the four standard lantern sizes used by the U.S. Lighthouse Establishment in the first half of the 20th century. Drawing assembled by WPTC from images dated 1898 and 1903 courtesy of USCG CEU Oakland.

Figure 4. Close-up of the fourth-order lantern at Coquille River Lighthouse in Oregon.

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.)

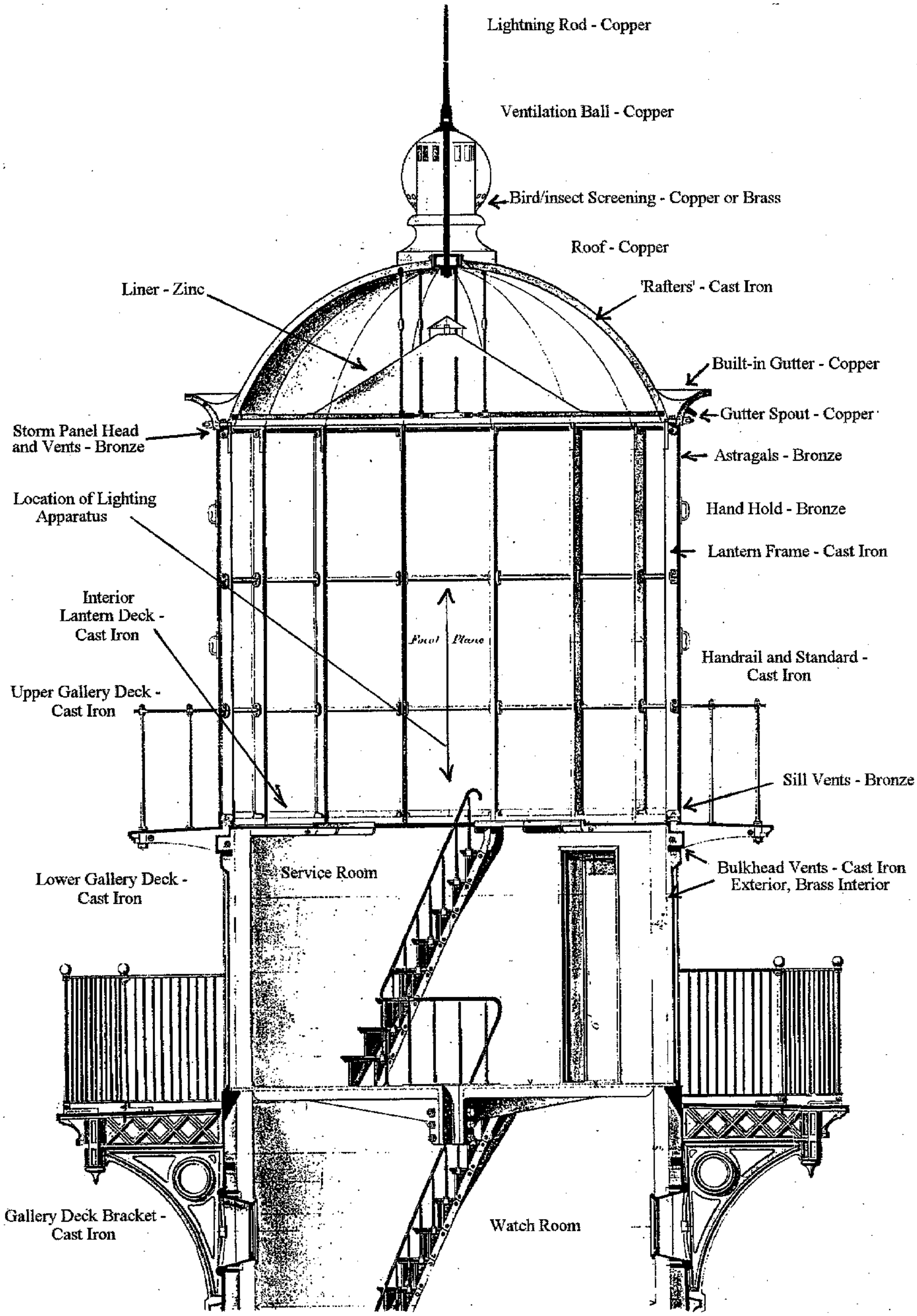


Figure 6. Diagram of a typical first-order lantern; the parts are similar to second- and third-order lights. (Diagram based on USLHS drawing in the National Archives)

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.

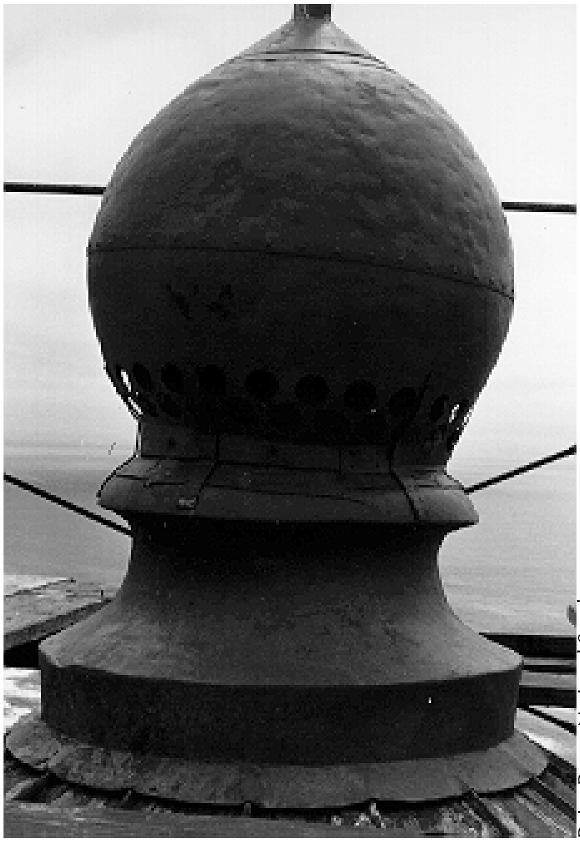
Rust-Jacking

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.

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.

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.

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.

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Figure 13. The paint coating that once protected this lantern parapet wall has failed.

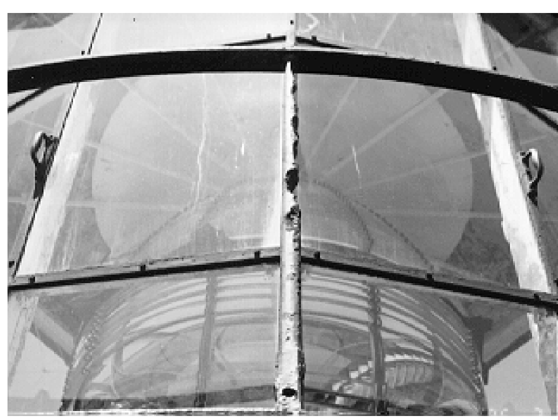

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Figure 14. Wind and airborne sand have accelerated the deterioration of this lantern gallery deck handrail

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.