INTERNATIONAL MOLYBDENUM ASSOCIATION
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A new stainless steel lighthouse

Lighthouses have been beacons for thousands of years, aiding navigation and guiding mariners to safe shores. New Type 316 stainless steel lighthouses are now making their contribution to safety at sea, reducing maintenance and environmental impact.

Lighthouses over the ages

Lights have warned mariners of danger since humans took to the sea. The first lighthouses in the western world were probably built somewhere on the Mediterranean Sea some three thousand years ago. In the Greek myth Leander and Hero, Leander would swim every night across the Hellespont (today's Dardanelles) to meet his lover Hero, guided by a lamp in her tower. As in many stories of ill-fated mariners, a storm arose one night that extinguished Hero's light and Leander lost his way and drowned.

The Eagle Rock lighthouse is located on a wild shoreline, whose breakers have on occasion hurled rocks through the lantern's windows.
© Gareth McCormack Photography

The first documented lighthouse was one of the ancient wonders of the world – the Pharos Lighthouse of Alexandria, built by Ptolemy I Soter after he announced himself king in 305 BCE. This huge lighthouse, thought to be 140 meters tall, existed until 1,303 CE when an earthquake destroyed it.

The British Isles experienced a "golden age of lighthouse building" during the 18th and 19th centuries. Hundreds of lighthouses were built to facilitate the rapid expansion of maritime commerce and military sea power driven by the Industrial Revolution. Despite this building frenzy, maritime disasters occurred routinely for many reasons including lack of adequate navigational aids. Lloyds of London estimated that between 1854 and 1879 over 50,000 wrecks were registered.

One of the "golden era" lighthouses was the Roancarrigmore lighthouse built in Ireland in 1847. The light is situated off the low-rising Bere Island, near the town of Castletownbere, and marks the eastern entrance to Berehaven Harbor. This is one of the world's largest natural harbors in Bantry Bay. A remote, unforgiving, but beautiful place, once used strategically by the British Navy, it is now a major fishing port and a harbor of refuge.

Although the Roancarrigmore lighthouse was updated in 1975 with a diesel generator and a sectored electric light flashing every three seconds, the Commissioners of Irish Lights (CIL) decided to replace it in 2011 after it had served reliably for 165 years.

Robert McCabe of CIL said: "Lighthouses are often seen by non mariners as historical or heritage curiosities with little functionality in today's modern world. This could not be further from the truth. Lighthouses have always been at the forefront of the technology of their day and the lighthouse in 2015 is no exception. The modern lighthouse uses energy efficient LED light sources powered by solar charged batteries and is often accompanied by radio aids to navigation such as Automatic Identification Systems (AIS), Radar Beacons (RACONS) or Differential GNSS (DGPS).

The availability of Global Navigation Satellite Services (GNSS) such as GPS, and others has revolutionized marine navigation and made a substantial impact on safety at sea. However, all GNSS services operate on similar frequencies and therefore suffer a common vulnerability to interference, jamming and spoofing. Space weather, local radio interference or intentional jamming can all result in GNSS denial on all systems over a large area. Alternative means of positioning provided by lighthouses such as buoys, beacons and radio aids to navigation are an essential complement and back up to GNSS. Visual aids to navigation are also important for spatial awareness and hazard marking and will be with us for many years to come."

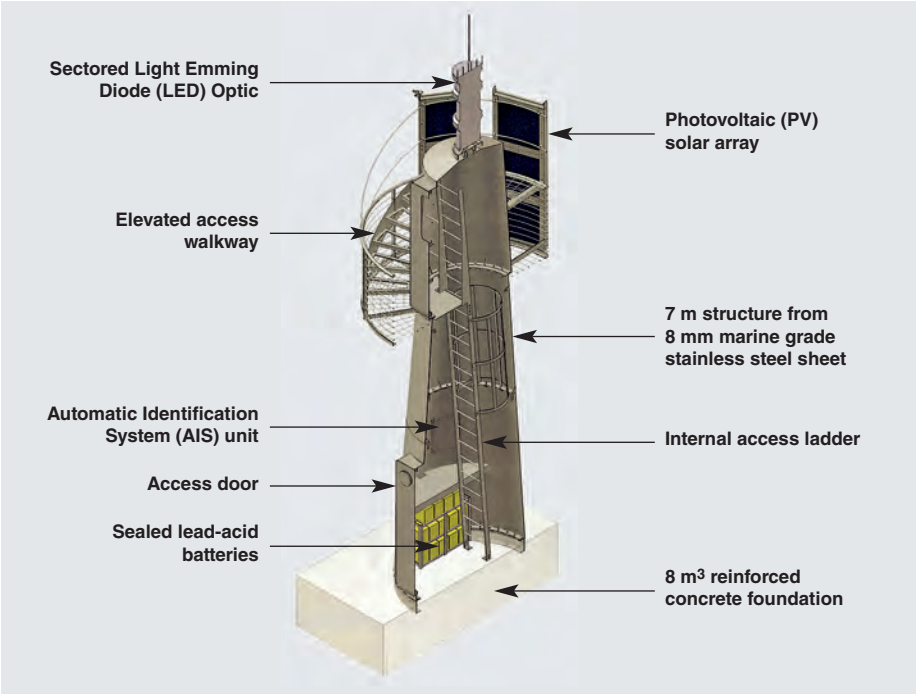
A new lighthouse where stainless steel shines

In 2010 a CIL review of its aids to navigation reclassified Roancarrigmore as a minor light with range reduced to eleven nautical miles, enabling a unique and innovative new design solution that replaced the existing lighthouse with a smaller modern alternative. ›

The original lighthouse comprised a stone tower with fully equipped residence, stores and engine room, all of which are expensive to operate and maintain. Requirements for the replacement were for it to generate its own energy, to exhibit its light at the required height while preventing excessive deflection of the optic, to minimise on-going maintenance, to provide basic facilities and shelter for visiting personnel, and to be consistent with the developing e-Navigation concept. The structure had to be strong enough to withstand the anticipated high winds, have sufficient corrosion and erosion resistance to withstand sea spray and any hurled rocks and debris, and be light enough to be lifted by helicopter to the site. The Board approved a final design in December 2010 that was simple, durable, inexpensive to maintain and cost-effective. The new lighthouse is a stand-alone Type 316L (EN 1.4404) stainless-steel structure, having an integrated and elevated photovoltaic solar array, internally located equipment and a flashing sectored LED light mounted on top. It includes an AIS transponder to provide for AIS and remote monitoring.

Due primarily to its higher strength and marine corrosion resistance, Type 316L stainless steel was chosen over aluminum, the only other material considered. The molybdenum content of Type 316L makes it the ideal choice because molybdenum provides high resistance to coastal corrosion. The alloy is also highly resistant to water and particulate erosion. The high-velocity wind and rain cleans the surface, reducing corrosive attack and lowering maintenance costs. The low carbon content of Type 316L makes it easily fabricated and welded.

Fabricating a shell section of the Roancarrigmore lighthouse tower. © Commissioners of Irish Lights



Cross-section of the new Roancarrigmore lighthouse, showing the location of its internal and external components. © Commissioners of Irish Lights

Tower construction

The tower stands on an 8 m^3 stainless-steel-reinforced concrete foundation built by pumping concrete from a mixer on a barge. Twenty-four No. 16 mm A4-70 Type 316 stainless-steel bolts secure the tower to its foundation. Natural circulation ventilates the structure to prevent gas build-up and reduce interior condensation. The tower is naturally lit for maintenance personnel and for building conditioning purposes.

CIL designed the new lighthouse and it was fabricated in three sections to CIL's specifications. The roughly conical main structure is 7 meters high, tapers from 2 meters diameter at its base to 1.2 meters at its top and weighs less than 4 tonnes. Bolted joints between sections incorporate internal rings to strengthen and stiffen the tower. The tower's internal volume provides storage for batteries, equipment and emergency supplies, and shelters personnel during day visits. Upper and lower doors, an internal ladder between floors, and a walkway at the top provide personnel access for maintenance. The walkway also serves to anchor the solar panel array used to generate electrical power.

The Tower's shell is made almost entirely from 8 mm-thick plate, rolled and welded into tapered circular hollow sections. Joints between the sections are sealed to prevent water entry. The internal elements, solar array structural components, balcony and walkways are also constructed from stainless steel. The tower has a matte finish to maximize its corrosion resistance, but it will assume a natural patina with the passage of time.

The tower's roof slopes upwards towards a ventilator and connection flange to which the pedestal for the optic is bolted. An air terminal, or lightning rod, connects to the structure itself and extends above the optics pedestal to become the tower's highest point. The tower is electrically bonded to the rock through ❯

The old Roancarrigmore lighthouse dwarfs the new tower of its replacement during construction.
© Commissioners of Irish Lights

its conductive concrete foundation, making it, in effect, a Faraday cage. Thus, in a lightning storm the safest place to be on the island is inside the tower.

Navigation aid fit-out

The new LED light is a three-tier sectored design that flashes once every five seconds and has a range of 11 miles white, 9 miles red. The low-voltage power system comprises twelve 50W, 12V solar panels that run the LEDs and charge sealed lead-acid batteries that provide power when the panels cannot. The system requires only an annual maintenance visit, and has significant environmental and cost benefits over the previous generators that burned almost 15,000 liters of diesel annually.

The AIS transponder does double duty, broadcasting its AtoN message and enabling remote monitoring of the facility. This mix of traditional and electronic systems is consistent with the e-Navigation concept that digitally integrates shore AtoN systems with on-board navigation equipment.

Installation

The tower structure was installed in November 2011. The sections were airlifted into place, lowered and oriented onto guides, and bolted to the previously installed section below after applying sealant. The installation, which required almost a year of planning, took the CIL less than three hours to complete.

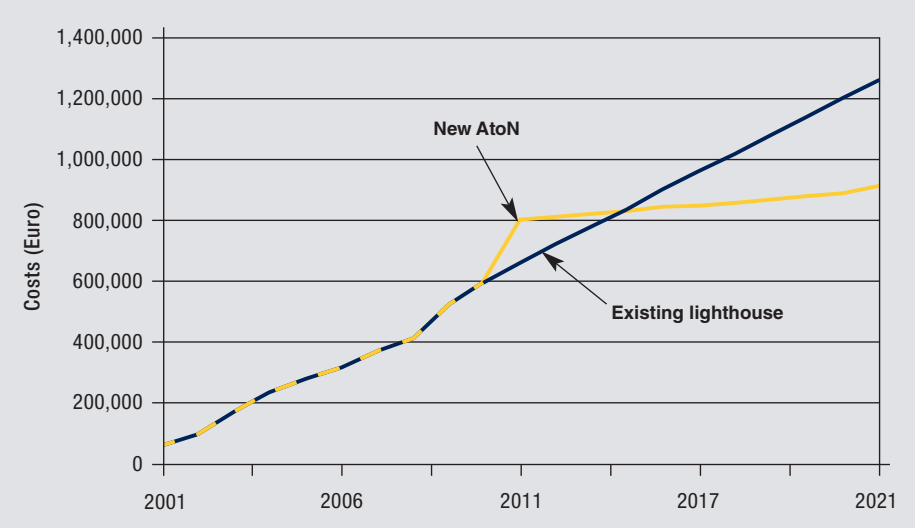
The mechanical and electrical fit-out of the lighthouse continued for another three weeks, and the new light began to operate in February 2012.

More stainless steel lighthouses

Certainly the most remote lighthouse, situated at the wildest location, is Ireland's Eagle Rock lighthouse, perched atop a 60-meter cliff off Black Rock, Sligo, in the far north of Ireland. This lighthouse is famous for withstanding Ireland's worst storms. In 1861, a storm mounted the cliff and broke the lantern's windows 67 meters above the mean ocean level. In 1894, waves flooded another tower that had been built at the site.

CIL built its second stainless steel AtoN at this storm-tossed site, replacing a 200-year-old lighthouse that had been modernized and automated in 1988. Sadly, the old tower's lantern room and domed roof had reached the end of their working life by that time. The dome, lantern room, large glass lens and mercury bath in which the lens rotated were all removed and replaced with a CIL-designed stainless-steel structure. The new light, which began to operate in November 2013, can be seen for 18 miles from the west with three white flashes every 20 seconds. Another stainless-steel light was installed at Mizzen Head in July of 2013, and plans for a fourth new stainless steel light for Glandore Harbor are complete.

The finished Roancarrigmore lighthouse, a new high-technology replacement for its venerable predecessor. © Commissioners of Irish Lights



Cumulative direct costs – existing lighthouse compared to the new aid to navigation (AtoN).
Source: Commissioners of Irish Lights

These new lights are steps along a road that will move lighthouses from structures of nearly solid granite to a new molybdenum-containing stainless-steel design that will serve equally well for a hundred years. Their beacons will shine as long as there are mariners at sea. (Curt Kovach)

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