NATATORIUM LIGHTING IN TODAY'S HIGHLY CORROSIVE ENVIRONMENT

This short guide is intended to offer general context based information on natatorium lighting. It addresses the common challenges related to meeting above ground lighting requirements which project managers will face .

Indoor pool lighting is arguably a complex undertaking when one considers the many variables involved. The goal is to produce a seamless integration between natural (daylight factor) and artificial light and to provide for safe levels of illumination and complement the architecture, aesthetics and furnishings of the space.

The primary concern is to provide appropriate lighting levels to render the space safe for the intended use as well as generating a positive user experience. Indoor pools range in uses from international/national level competition to community sport complexes or local high school swimming pools.

In all cases life safety and accident prevention are the driving forces behind a specific lighting design and many resources are available to achieve this goal. Adequate light levels as well as light uniformity and quality are also important. Additionally since water is a good reflector, glare control strategies must be employed. A few recommendations are included in this guide.

When selecting a natatorium service luminaire one must consider the highly corrosive environment. Long luminaire service life and reliability are essential for reducing maintenance, nuisance disruptions and service costs.

To achieve a balance between the ideal and the practical, a successful project manager will need to evaluate the following seven elements:

Safety
Light Levels
Environment
Product Service Life
Reliability
Maintenance
Light Quality & Aesthetics

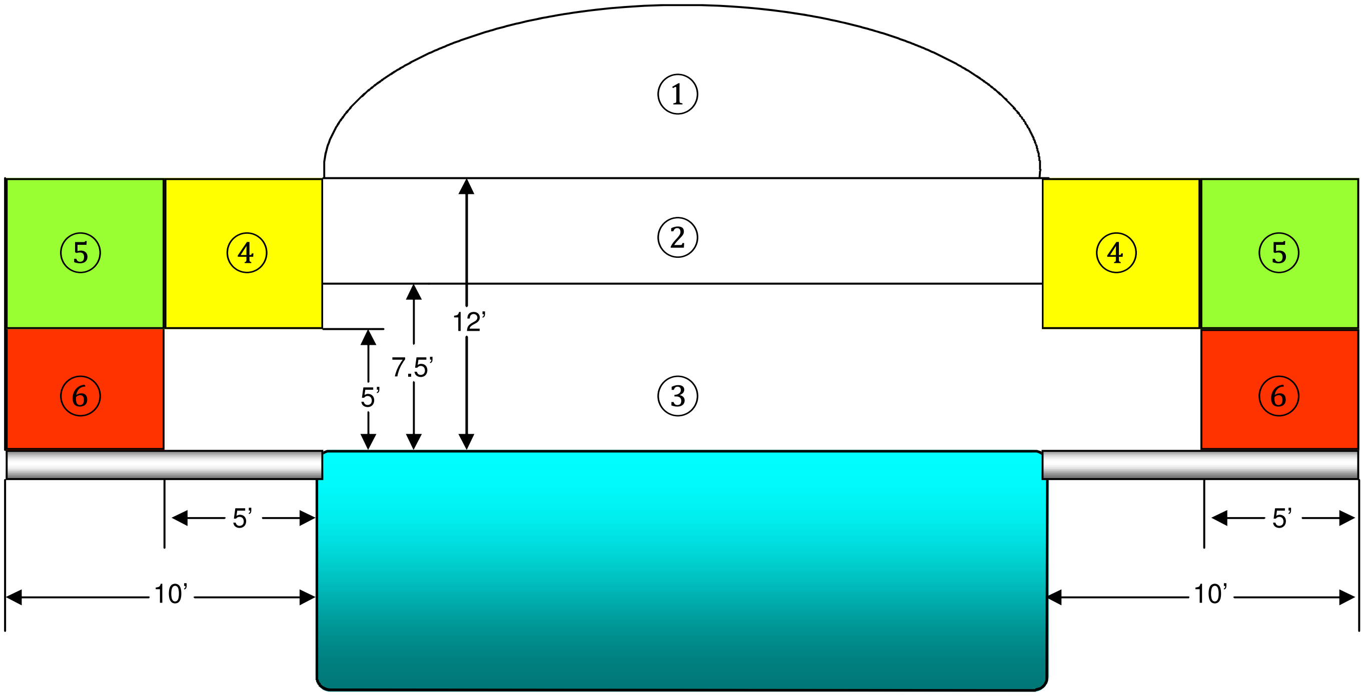
Choosing the right lighting technology and product is essential for long term performance. Only products designed to operate within a pool's corrosive environment stand any chance of surviving long term.

Safety

Lighting safety is governed by various agencies including the National Electrical Code (NEC) in the USA and by the Canadian Electrical Code (CEC) in Canada.

The pool council and many other agencies also contribute to the standards and regulations as well as municipalities and any Authority Having Jurisdiction (AHJ) such as state/province, counties and municipalities. Furthermore the Institute of Electrical and Electronics Engineers (IEEE), the American National Standards Institute (ANSI), Underwriters Laboratories (UL) as well as National Fire Protection Association (NFPA) have rigid guidelines for lighting applications near water.

Below is a diagram adapted from the NFPA70 NEC 2008 art. 680 on accepted luminaire placement and restrictions.



1. Above 12 foot over water all fixtures are permitted
2. When protected by GFCI totally enclosed (wet locations) fixtures permitted
3. No fixtures are permitted below 5 foot.
4. Only existing rigidly attached fixtures permitted.
5. New fixtures permitted without GFCI .
6. New fixtures permitted when protected by GFCI

Light Levels

Lighting Levels and uniformity recommendations are produced by the Illuminating Engineering Society of North America (IESNA) RP-06-01 for Sports Recreational Area Lighting. Some state/ province, counties and municipalities also mandate minimum natatorium light levels of 40-foot candles or 50-foot candles.

Lighting Levels & Uniformity per Class:

Class	I Professional Class	II Collegiate Class	III Intermediate Class	IV Recreational Class
Pool (fc)	75fc	50fc	30fc	30fc
Deck (fc)	50fc	20fc	10fc	10fc
Pool Uniformity (u)	1.7:1 max/min	2.5:1 max/min	3:1 max/min	4:1 max/min
Deck Uniformity (u)	2.5:1 max/min	4:1 max/min	4:1 max/min	4:1 max/min

The project manager must verify with the local authorities having jurisdiction before attempting to define horizontal and vertical illuminance levels.

Uniformity & Unified Glare Rating (UGR):

Properly modeling the space with lighting design software will assure that light levels and uniformity meet minimum safety requirements. Luminaire type, quantity, distribution pattern and placement will have an effect on uniformity.

Luminaire placement height is another factor which also influence uniformity and this can be taken into account during the lighting modeling phase. Many regulatory agencies specify lighting levels that will provide at least 30 foot candles of illumination on the deck and pool area. Consult the specific requirements of the appropriate regulatory agency if competitive swimming events will be conducted.

International Swimming Federation (FINA) & United States Swimming (USS) rules for championship meets require a minimum of 40-foot candles of illumination 3 feet above the water. For night time or indoor competition, 100-foot candles are necessary at start and turning ends. Official Olympic pools may require up to 140-foot candles (1500 lux). Area lighting should be designed to reduce direct glare and reflections on the water surface.

Special attention must be paid to the negative effects of glare. Glare is a serious problem in an aquatic environment. Glare can be described as direct or reflected glare, which can then result in discomfort or disability. Glare can be dynamic when the water surface is in motion.

Safety personnel are highly dependent on adequate lighting levels to perform their tasks. Glare is a problem when light reflected from the water surface creates a veil & reduces their ability to discern underwater shapes and conceals the activity of bathers. This is especially true when underwater sport events are practiced such as underwater hockey, underwater rugby, fin swimming and sport diving as well as teaching diving, lifesaving and scuba diving techniques.

Lighting fixtures directly facing the user can also cause glare when contrast levels are high. This can possibly also indicate poor uniformity values with incorrect luminaire types or with fixture spacing that is too large. Consider light fixtures that minimize glare and shadowing.

Glare can be controlled by placing fixture around the perimeter of the pool and deck area.
A combination of both up lighting and down lighting on walls offers a great solution. Indirect lighting with white or off white ceilings also works well. However indirect lighting methods increase costs since their dependence on available reflectance reduces available light. When practical, ceilings and walls should be painted matte to eliminate glare emanating from those surfaces. Wet & dry niche underwater lighting can also greatly aid in reducing veiling.

Additionally fixtures should be accessible from the deck area with portable ladders, scaffolding or hydraulic lifts and should not be placed directly over water unless a catwalk is provided for maintenance.

The overall lighting scheme can also greatly benefit from the proper integration of dimmers, schedulers and daylight harvesting sensors. Their cost is usually recovered within 12 months of operation and are interesting additions to optimize user comfort and decrease the system's energy usage.

Environment

Pool lighting is subject to an extraordinarily corrosive environment. Chloride clusters formed as a result of the evaporation of water droplets can give rise to localized corrosion. Over some years, aquatic complexes have seen an increase in their swimming pool hall temperature and have been equipped with jets, slides, etc., promoting the development of a more corrosive atmosphere than previously encountered.

Chemicals Normally Used to Treat Swimming Pool Water:
Typical inorganic chlorination agents: calcium hypochlorite, lithium hypochlorite, sodium hypochlorite.

Typical organic chlorinating agents: trichloroisocyanuric acid, potassium dichloroisocyanurate, sodium dichlorocyanurate (as anhydrous or dehydrate forms).

* Sanitisers / disinfectants - To destroy harmful and objectionable organisms.
* Soda Ash (sodium carbonate) / pH Plus - Used to increase the pH level.
* Sodium bisulphate / pH Minus - Used to decrease the pH level.
* Chlorine Stabiliser - To prevent unnecessary loss of chlorine.
* Algaecide - To kill and prevent the growth of algae.
* Filter Aids / Flocculants / Clarifiers - To help remove foreign debris / material.

Salt-water chlorination works by having an electrolytic cell break down the salt (Sodium Chloride) dissolved in the water in order to produce chlorine that acts as the sanitizer use of chlorine stabilizer - cyanuric acid - (also causing additional damage to pool lighting), algaecide, clarifier and sequestering/chelating agents. By-product gases such as volatile tri-nitrogen chloride (trichloramine) which is acidic and corrosive.
Tri-nitrogen chloride is formed by a reaction between chlorine and ammonium under acidic conditions in the water.

Ambient Air Temperature: The air temperature of the pool environment is usually set higher than the temperature of the pool water to prevent condensation from occurring on interior surfaces. The norm is between 2 to 4 degrees warmer than the water temperature. The range of water temperature typically varies between 76°F (25°C) for competition level pools to 96F (36°C) for therapeutic use.

Humidity level: Humidity should be approximately 50-60% however under special conditions this value can reach 80% or more. The use of in water and deck jets, water slides and various aquatic playground equipment increases the humidity level in the air. Typical water evaporation can be significant and rates are between 40-400lbs of water/hr depending on pool size, water and air temperature & humidity. Newer natatorium designs will use negative air pressure to control the ambient environment including propagation of humidity to adjacent areas.

Utilizing the correct choice of materials in lighting fixtures is essential for long term reliability in difficult environmental conditions. *The Main Types of Materials are:*

Cast Iron
Stainless Steel
Brass
Aluminum
Zamark
Chrome
Composites
Plastics/Marelon/PVC

However only Stainless Steel and Aluminum are well suited for light fixtures exposed to the strong chemicals and the high humidity found in natatoriums.

Stainless Steel is quite resistant to rust & corrosion but will eventually succumb unless the surface is treated with an appropriate coating. However once this coating is breached rust will set in very quickly and structural integrity will suffer. This is caused by the iron content in the steel being exposed to humidity and air.

Stainless Steel is an alloy containing a minimum of 50% iron and 10% chromium. The percentage of chromium varies between 10% & 30% with higher chromium content providing increased corrosion protection. Stainless steel alloys are grouped according to the structure of their crystals.

Adding nickel creates austenitic stainless steels, identified by their 300-series designation. Most stainless produced today is Type 304, a low-carbon variation of 302, also called 18-8 because it's made of 18% chromium and 8% nickel and may be referred to as A2. There are many 304 sub-alloys formulated for specific applications.

When stainless steel is produced, the chromium forms an outer oxide layer. As long as that layer remains intact, the stainless remains passive. To prevent corrosion, the passivated stainless steel is immersed in a heated bath of phosphates or salts.

This solution forms an oxide film that seals off the iron, preventing it from going into solution in water. Once the oxide layer begins to break down, the stainless steel becomes active and its corrosion resistance is reduced. Rust is the obvious, visible evidence of corrosive activity.

There are a variety of ways in which the oxide layer is compromised. These include pitting and crevice corrosion caused by microscopic water-retaining cracks or scratches, microscopic impurities, galvanic corrosion, corrosion fatigue and stress fatigue cracking. The corrosion that results will likely be invisible or difficult to detect.

316 Stainless Steel highly recommended for use whenever heat, high humidity, acids and chemicals are present. The formulation of 316 will outlive 302, 304 Stainless Steel designations under the same corrosive conditions. Furthermore not all 300 series formulation are adequate for use in corrosive environments.

The elevated cost of well designed and manufactured Stainless light fixtures as well as the possibility of corrosion are major concerns.

Aluminum also performs very well and similarly should be surface treated or coated to promote long life. Once the surface treatment is breached a gradual appearance of surface pitting will occur which will not affect structural integrity.

Aluminum cost is reasonable and allows for more complex designs that have smaller footprints. Additionally it is lighter and luminaires operate at lower temperatures.

Metal Corrosion in Open Air:

The corrosion of metals in the open air depends on the so-called time of wetness and the composition of the surface electrolytes. The time of wetness refers to the period during which a metal's surface is sufficiently wet for corrosion to occur. The time of wetness is normally considered when relative humidity exceeds 80% and, at the same time, the temperature is above 32°F/0°C (e.g. when condensation forms).

The presence of salts (particularly chlorides) in the air reduces aluminum's durability, but less than in the case for most other construction materials. Maximum pit depth is generally only a fraction of the thickness of the material. Thus, in marked contrast to carbon steel, strength properties remain practically unchanged.

The following section will address common types of Aluminum corrosion.

Galvanic Corrosion (Aluminum in a Solution):

Galvanic corrosion may occur where there is both metallic contact and an electrolytic bridge between different metals. The least noble metal in the combination becomes the anode and corrodes.
Galvanic corrosion of aluminium occurs:

- Only where there is contact with a more noble metal (or other electron conductor with a higher chemical potential than aluminium, e.g. graphite).
- While, at the same time, there is an electrolyte (with good conductivity) between the metals (immersion).

The risk of galvanic corrosion must always be taken into account in environments with high chloride levels where the Aluminum will be continuously within a solution of the chemical.
This is not an issue with wall mounted or suspended luminaires not directly immersed in a solution as in a wet niche pool light or other continuously immersed pool hardware.

Pitting & Crevice Corrosion:

Pitting is primarily an aesthetic problem that, practically speaking, never affects strength.
Attack is, of course, more severe on untreated aluminium. Surface treatment (anodising, painting or other coating methods) counteracts pitting. Pitting can be prevented by cathodic protection (above). It is also important to design profiles so that they dry easily.

Corrosion of aluminum in the passive range is localized, usually manifested by random formation of pits. The pitting potential principle establishes the conditions under which metals in the passive state are subject to corrosion by pitting.

For aluminum, pitting corrosion is most commonly produced by halide ions, of which chloride (Cl) is the most frequently encountered in service. Pitting of aluminum in halide solutions open to the air occurs because, in the presence of oxygen, the metal is readily polarized to its pitting potential.

Pitting Prevention in Aluminum:

Anodising

Thanks to the protective and self healing properties of the natural oxide layer, aluminium shows good resistance to many chemicals. Anodizing is one of the many coating options available. The application of anodising greatly increases the finish longevity and product appearance.

Anodising is a technique to thicken the natural oxide layer by placing the metal as the anode in an electrolytic cell. There are different systems for anodising but all of them intend to increase the oxide layer to a thickness of 1000-10 000 times its natural thickness (in the order 5-10 nm).

Anodising gives a porous oxide film with micro-pores. As an after-treatment the pores are sealed by transforming the aluminium oxide into Boehmite. The anodising gives a better corrosion resistance, improves the resistance to abrasion and improves the adhesion of coatings, as well as alters the dielectric and optical properties.

Product service life

A natatorium fixture must meet safety guidelines, the required photometry criteria, provide high efficacy, low operating costs and Total Cost of Ownership (TCO), ease of installation, service life beyond projected calculations, low or no maintenance, aesthetic appeal, simple serviceability in case of failure and have a solid performance based warranty.

These requirements influence luminaire design hence LEDRays has chosen the very best materials to engineer its natatorium series luminaires.

HPFM Series Natatorium LED Luminaires

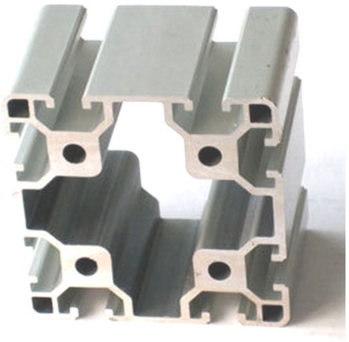
Features

- Unique Heatsink Offering Unparalleled Thermal Capability
- Nichia™ Structured High Power LED Array.
- 40W to 300W+ in a Fully Modular Design
- Lensing Flexibility Provides Optimized Photometric Distribution
- Very High Efficacy >105lm/w & 31500lm for 300W
- Digital Driver with 5 way I²O Protection
- Exceptional Power Factor & Low THD
- AC100-508V Range
- Aluminium Extrusion & Stainless Hardware for Extreme Reliability
- Highly Customizable for Application Specific Performance
- 50,000hrs L70 at 30°C Ambient

Aluminum Alloys in the HPFM Series Natatorium LED Luminaires:

Marine & Aerospace Aluminum Alloy AA5052 (H32)

The alloy composition of 5052 is:
Magnesium - 2.2%-2.8% by weight
Chromium - 0.15%-0.35% maximum
Copper - 0.1% maximum
Iron - 0.4% maximum
Manganese - 0.1% maximum
Silicon - 0.25% maximum
Zinc - 0.1% maximum
Others each 0.05% maximum
Others total 0.15% maximum
Remainder Aluminum



Mechanical Properties:
Yield Strengths

Hardening	Ultimate MPa (PSI)	Tensile MPa (PSI)
H32	228 (33000)	193 (28000)

Marine & Aerospace Aluminum Alloy AA6063 (T6)

The alloy composition of 6063 is:
Silicon minimum 0.2%, maximum 0.6% by weight
Iron no minimum, maximum 0.35%
Copper no minimum, maximum 0.10%
Manganese no minimum, maximum 0.10%
Magnesium minimum 0.45%, maximum 0.9%
Chromium no minimum, maximum 0.10%
Zinc no minimum, maximum 0.10%
Titanium no minimum, maximum 0.10%
Other elements no more than 0.05% each, 0.15% total
Remainder Aluminum

Basic Properties:
6063 has a density of 2.68g/cm^3 (0.0975 lb/cubic inch)
T6 temper 6063 has an ultimate tensile strength of at least 28,000 psi (196 MPa) and yield strength of at least 23,000 psi (165 MPa).

The HPFM Series Natatorium LED Luminaires Implements the Following Design Strategies.

Ultra low void on LED modules
Fully encapsulated drivers
Lensing options for optimal distribution
Superb light quality with high CRI and smooth spectral content
Exemplary power quality performance with .98 power factor and ≤14% THD
Multiple cleaning, rinsing and a preparatory stages prior to anodising
Lens are PC hard coated with exceptional light transmission characteristics
Drainage channels
340 Stainless fasteners
Sealed to IP68
5 Year performance warranty

Reliability

Various types of artificial light technologies are available to the project manager, however when it comes to reliability and product longevity solid state technology is a clear choice. Servicing lighting in a pool hall causes major operation disruptions. Through proper design, manufacturing and testing LED luminaires can achieve extreme dependability and long life.

A LED luminaire will use less energy, produce less heat and require practically no maintenance unlike traditional filament and gaseous light fixtures. Thus nuisance disruptions caused by breakdowns & failures, relamping and routine maintenance are practically eliminated in a well engineered LED lighting system.

Light depreciation of LED is substantially minimized when compared to traditional light types such as gaseous & filament. Additionally the output demonstrates increased stability over time. The life expectancy of LED luminaires can certainly exceed >75,000 hours at 77°F/25°C ambient. This hour value is defined as the useful life. It is the point at which light output has declined to 70% of initial lumens (abbreviated as L70) as per IES LM-80 & TM-21 protocols.

Reliability may be defined in the following ways:

- The idea that an item is fit for a purpose with respect to time
- The capacity of a designed, produced or maintained item to perform as required over time
- The capacity of a population of designed, produced or maintained items to perform as required over specified time
- The resistance to failure of an item over time
- The probability of an item to perform a required function under stated conditions for a specified period of time
- The durability of an object.

Light Quality & Aesthetics

Color Rendition: The project manager will need to choose a lighting system and technology that achieves the desirable light quality. LED Luminaires with high CRI values >80 are recommended. Particular attention to the critical R9 value (Red) is important to attain a balanced and faithful color reproduction.

Incidence Angle: To control problematic reflective veiling and glare, the lighting design should limit the angle of incidence to a maximum of 50 degrees.

Spectral content: The spectral content of the light source must be analyzed for strong discontinuities. The appropriate color corrected temperature (CCT) must be selected to optimize light output and create a pleasant and natural atmosphere without ocular discomfort.

Correlated Color Temperature: Values of 3000-4500K are appropriate for leisure & recreational sites while 4500-5500K may be required for competition level sites using broadcasting equipment.

The lighting scheme should additionally apply symmetry and simplicity to the layout in order to bring out elemental features and highlight interesting areas of the space. However high contrast areas should be avoided since it can distract the attention of lifeguards towards the pool basin.

Ultimately a properly integrated lighting system will not draw attention to itself. Rather once the safe lighting guidelines have been meet the lighting system can add another dimension of visualization and presentation of the space.

About us:

Discover how our 10 years SSL experience and over 20 years in engineering will help you in your search for top performing LED products. Solid LED knowledge and a team of passionate professionals can make your next LED integration a success.

We earned our stars in manufacturing luminaires for harsh environment, complex conditions and high power LED lighting applications for OEM customers. We thrive on challenges and custom projects are our specialty.

With our in house photometry, electrical and thermal labs we are the best value in the specialized LED lighting market.

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