

TerranearPMC Safety Share

Week of October 17, 2011 – Illumination

The Autumn Equinox has now past and therefore the evening hours have overtaken the daylight, only to continue its encroachment on our hours of sunlight rendering the days to grow dimmer as we near the Winter Solstice. Hence, while we may have field work that is technically designed to be performed during the day, we may find ourselves starting and ending our work shift in darkness. As such, we may need artificial light sources to ensure that a certain level of visibility is maintained while we perform our assigned tasks. Without proper lighting, uneven surfaces, steps, rocks, as well as equipment and materials that are left on the ground (due to poor housekeeping) become more pronounced and represent greater “slip, trip and fall” hazards than what they were during the daylight hours.

Illumination is typically expressed in units of foot-candles (fc), lux (lx), or lumens (lm). The most popular, fc, is used to define illumination at many sites where hazardous waste operations need to comply with the OSHA HAZWOPER standard (29 CFR 1910.120 and 29 CFR 1926.65 for general industry and construction, respectively). At Army Corp of Engineer (ACE) work sites, lx (with the conversion of lumens per square feet (lm/ft^2)) is the accepted unit of measurement.

The term, fc, is defined as the amount of illumination provided by a candle within a 1-foot spherical radius. However, that is quite a subjective quantifier; after all, different candles will vary in brightness. In more scientific terms, that candle needs to have a certain intensity, defined as a candela (Latin for candle), that emits a single wavelength frequency at a power equal to 1/682 watts over a solid spherical angle known as a steradian (12.57 steradians equal an entire sphere). If this sounds a little complicated, that’s because it is! Some of the greatest scientists, such as Max Planck (the founder of quantum physics) made contributions to properly quantify illumination.

While the fc is not considered to be the accepted international system to measure illumination (more commonly referred to as the SI unit), the lumen (lm) is. When the light intensity of one lumen is emitted uniformly over one square meter, the unit measurement is known as a lux. Therefore, one lux is equal to one lumen per square meter (hopefully, it is apparent that the term lux takes area into consideration, while lm generally requires an area to be included). In the ACE Safety and Health Requirements Manual, EM-385-1-1 (Section 7), illumination requirements are expressed in lux, which, in contrast to OSHA’s HAZWOPER requirements, illumination is expressed in fc. While the actual definitions of fc, lx and lm may or may not be fascinating to you, the important point is to understand how to convert fc to lx, as, depending on the type of light meter being used, you may only be provided with one unit or the other. The conversion is simple, relating these two units by the following:

$$\mathbf{1\ fc = 10.764\ lux}$$

Note that $1\ \text{m}^2$ equals $3.281^2\ \text{ft}^2$ or $10.764\ \text{ft}^2$: thus $1\ \text{fc} = 1\ \text{lm}/\text{ft}^2$! That means it’s a straight one-to-one conversion from fc to lm/ft^2 and vice versa.

Both OSHA and the ACE have tables that present minimum illumination values. Below is an example of OSHA requirements from 29 CFR 1910.120, Table H-120.1

OSHA HAZWOPER Illumination Requirements

fc or lm/ft ²	Area or Operations
5	General site areas.
3	Excavation and waste areas, accessways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: Warehouses, corridors, hallways, and exit ways.
5	Tunnels, shafts, and general underground work areas. (Exception: Minimum of 10 foot-candles is required at tunnel and shaft heading during drilling mucking, and scaling. Mine Safety and Health Administration approved cap lights shall be acceptable for use in the tunnel heading.)
10	General shops (e.g., mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing rooms, dining areas, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices.

Note: ACE values are the same for the above-listed areas/activities except for maintenance shop areas where the ACE illumination requirement is 30 lm/ft²

Full unobstructed sunlight has an intensity of approximately 10,000 fc. An overcast day will have an intensity of around 1,000 fc, while the intensity of light near a window can range from 1,000 to 5,000 fc, depending on the orientation of the window, time of year and latitude. Therefore, when compared to natural sunlight, the OSHA/ACE minimum illumination requirements are, indeed minimal. So with proper lighting at your work location, meeting the regulatory requirements should not be difficult. However, while regulatory compliance is necessary, the main concern should be whether on-site lighting has indeed provided adequate illumination so that personnel can perform their job tasks safely. This necessitates an on-site assessment via a walkthrough of each area (having a person that works in the area accompanying you is always a good idea). As a rule of thumb, if workers can perform their assigned tasks without any visible impairment, then the area's illumination will meet regulatory requirements.

Even though workers may indicate that their work location appears to have adequate lighting, appropriate monitoring as well as documentation still needs to be performed. Because there are so many types of light meters, it is important to select the right instrument. Make sure the instrument output displays the illumination values in the units you need as well as verifying it is designed to function in the specific working range. Also depending on the light source (incandescent, halogen, etc), a correction factor may be necessary while the manufacturer may indicate that the meter is held at a particular orientation with regards to the light source.

As a conclusion to illumination, when working during evening hours or in areas where visibility is somehow compromised (enclosed location, "cold and dark" abandoned buildings, etc), it is important that proper lighting is available. Meeting the regulatory requirements may be important, but ensuring the safety of your workers should always be the bottom line!

"Hide not your talents, they for use were made. What's a sundial in the shade?"

-Benjamin Franklin