Lighting for Gymnasiums

— Eric Strandberg LC

Above: The University of Montana Recreation Center with Daylight only.

With all the new school construction going on in the region, the Lab has been asked to comment frequently on lighting for gymnasiums. Good lighting for gymnasiums would seem to be a simple task but as we try to design systems that are energy efficient, versatile, and provide high quality light, it can become rather complicated. Additionally, with the new light sources and fixture types, the old tools and rules of thumb become less viable.

The first type of lighting that should be considered for every new project is daylight. Gymnasiums generally are; large volume, high ceiling, and single story, making them excellent candidates for skylights. Additionally, their hours of operation coincide nicely with availability of daylight. However, there will be times when electric lighting will be needed to either supplement low levels of daylight or for night time activities. This article will address those concerns.

For the past few decades the standard practice has been to use Metal Halide "High Bay" type fixtures. When this kind of lighting first became available it was a marked, if idiosyncratic, improvement to the old generation of fluorescent, incandescent, and mercury vapor lights that were used until then. On the positive side, standard Metal Halide (MH) has a number of good properties. It has high lumens per watt, (efficacy), and fairly long life, both of which are of importance to building operators. Also, because gymnasiums are tall spaces, a degree of optical control is desired to distribute the light properly. Because Metal Halide is a point source it is well suited for this task and can lead to lighting layouts that use fewer fixtures than with older technologies. However, standard MH does have some properties that are less than favorable, and I will list them below.

- **Strike time:** MH lamps take about 3-5 minutes to come to full brightness after they are energized. (This strike time makes them a poor choice for spaces that are using occupancy sensors and /or daylight controls).
- **Restrike:** If there is a power interruption, even for a second, the lamps need to cool down and then start the strike cycle again. This process can take over ten minutes. This also necessitates a redundant lighting system be in place for safety and egress.
- **Color shift:** In general MH lamps produce a stark white light, but over time the lamp color can shift toward blue, pink, green or purple with no consistency from lamp to lamp.
- **Lamp lumen depreciation:** All electric light sources get dimmer over time, a light source that loses as much as 15 to 20% of light over its life is considered acceptable. Standard MH lamps can loose up to 50% of light before they finally fail (this characteristic is also called Lumen Maintenance).
- **Poor color rendering:** How well a light source reveals colors accurately is charted on the Color Rendering Index (CRI) a scale from 0 to 100. The higher the number the better the light source reveals true colors. Standard MH, has a rather mediocre CRI of about 65, this leads to flat skin complexions and drab looking interiors. Better color discrimination aids vision, which is important in a high activity area like a gymnasium.
- **Harsh shadows:** A point source, though increasing optical control, does also render shadow very precisely. This can lead to distracting patterns and areas of bright and dark. Additionally, a point source is by definition very bright, and in a poorly designed or applied fixture, can yield intense glare to the users of the space.
- Pulse Start Metal Halide and Ceramic Metal Halide have alleviated some of these problems. Pulse Start lamps provide incremental improvements in strike and restrike time, lumen maintenance, reduced color shift, and efficacy. Ceramic Metal Halide lamps have greatly improved CRI (in the 80's) and minimal color shift.

Given these unfavorable properties, why is MH still the standard practice light source used in athletic facilities today? I think it is a lack of awareness of the new fluorescent products available and the benefits of using them. This article is an effort to demonstrate the differences and advantages of fluorescent lighting in these applications. I will model a typical gymnasium space with a variety of lighting strategies and compare the results.

A) Standard Metal Halide high bay

Above is a typical lighting layout for a 75' X 100' single court gym area w/ a fixture height of 26'. The reflectances are 70% for the ceiling, 60% for the walls, and 30% for the floor. Not only will we look at power consumption and light level but also uniformity, expressed as Max to Min ratio. Uniformity describes how evenly the space is lit and for this type of space having evenly distributed light is important not only for the field of play but for the surrounding visual field.

The advantages of fluorescent systems are many and can be categorized as follows:

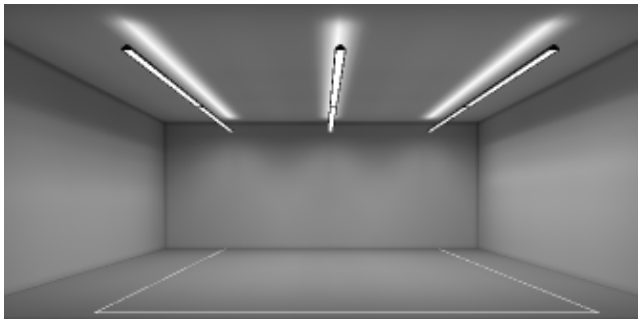
- **High lumens per watt:** (in the 90 range). High lumens per watt mean lots of light for less energy. This results in energy savings as seen in the table below.
- **Excellent lumen maintenance:** T8 and T5 lamps lose only about 10% of their light over their life. That means that the light that the system starts with will be about as much it will deliver when the lamps are changed.
- **Excellent Color Rendering:** Common fluorescent lamps can have a CRI in the 80 range. This gives objects and colors a clarity and definition that aids in visibility. Studies suggest that people require less, high CRI light to achieve the same visual accuracy as low CRI light.
- **Instant strike and no "restrike":** This means that the lights will come on immediately and if they are switched off, they can be turned back on right away if necessary. This makes for easy adoption of control systems based on occupancy or daylight conditions. Energy savings and longer maintenance intervals will result if the lights are turned off when not needed. It should be noted that frequent on/off switching of fluorescent lamps results in shortened lamp life. This can be minimized by using program start ballasts and a longer occupancy control interval.
- **Softer shadows:** Because fluorescent tubes are large radiant surfaces, they tend to deliver diffuse, even illumination, making for lower contrast and increased uniformity of light. A possible downside of using fluorescent systems is that they require more lamps than MH systems (as indicated below), and the fluorescent tubes have reduced light output in chilly spaces.

I will model a typical gymnasium space with a variety of lighting strategies and compare the results. Shown is a typical lighting layout for a 75 ft x 100 ft single court gym area with a fixture height of 26 ft. The reflectances are 70% for the ceiling, 60% for the walls, and 30% for the floor. Not only will we look at power consumption and light level, but also uniformity, expressed as Maximum to Minimum ratio. Uniformity describes how evenly the space is lit and for this type of space having evenly distributed light is important, not only for the field of play, but for the surrounding visual field.

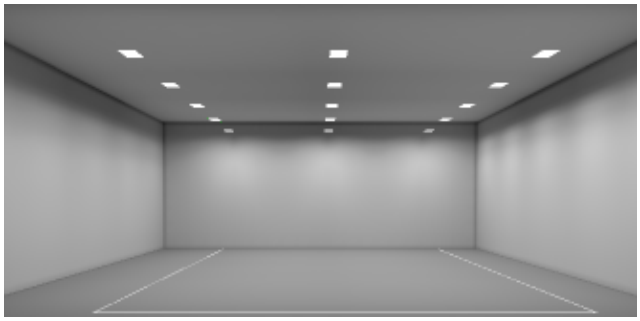
Let's look at the fixture types used in this example:
A) Baseline 15- a standard 400 watt Metal Halide High-bay w/ glass reflector
B) 63 -2 lamp 32 watt T8, 4' industrial w/ specular reflector and 10% uplight (in 3 rows)
C) 15- 4 lamp 54 watt T5 High output 2'x 4' "High-bay" w/ specular reflector
D) 15- 8 lamp 42 watt CFL High-bay w/ acrylic reflector
E) 14- 8 lamp 40 watt Biax Wrap style w/ Prismatic lens
F) 15- 6 lamp 32 watt T8 High-bay w/ specular reflector

Fixture	Avg Type	Max	Max /Min	W/Ft²
A) 400W MH X 15	28.8	37.9	4.2	.9
B) 32W 2 lamp T8 X 63	28.5	40.5	4.2	.5
C) 54W 4 lamp T5 X 15	28.5	35.8	3.1	.5
D) 42W 8 lamp CFL X 15	27.1	34.2	3.0	.6
(E) 40W 8 lamp Biax X 14	27.7	38.9	4.5	.6
(F) 32W 6 lamp T8 X 15	25.0	33.6	4.2	.5

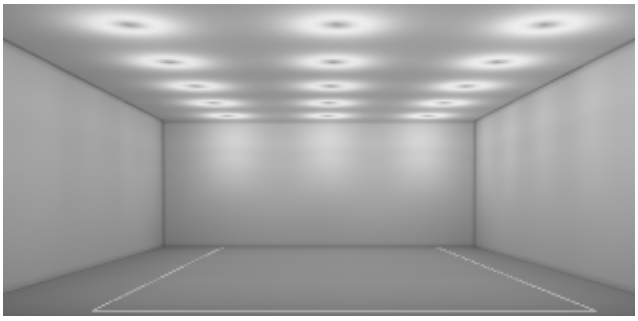
Note that fixture type C has the "best" blend of light output, uniformity (Max/Min), and low power.



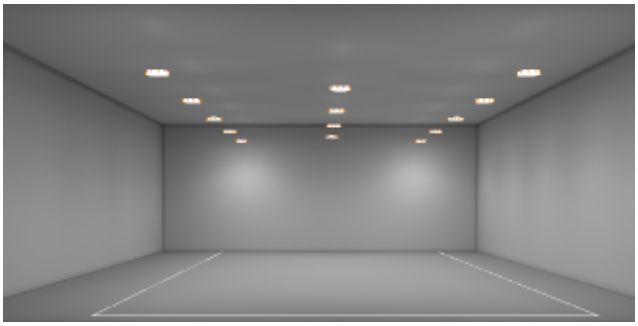
B) Fluorescent T8 in continuous rows



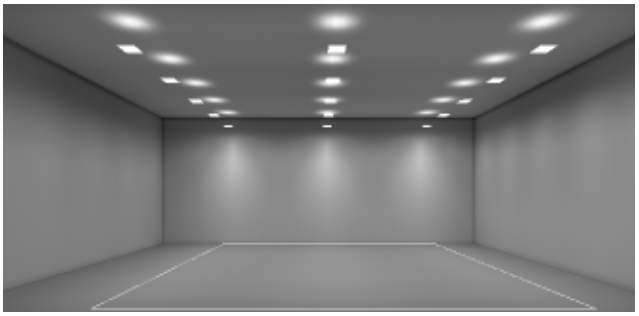
C) Fluorescent T5 HO high bay



D) Compact Fluorescent high bay



E) Fluorescent high bay wraparound prismatic



F) Fluorescent high bay w/ specular reflector

While no one system is perfect, I think it is clear from these examples that the fluorescent systems have lower power, good uniformity while maintaining more than adequate light levels.

Eric Strandberg, one of the Lighting Design Lab lighting specialist, has over fifteen years in the lighting industry. He studied theater and film lighting at The Evergreen St. College, Oly., WA, receiving a BA in Lighting in 1987. From 1985-90 he operated a lighting production company doing live and film work. In 1990 Eric switched to architectural lighting sales and design in the Seattle area. Coming to the Lighting Design Lab in 1995 he brings this background in an effort to promote good design and energy efficiency on commercial projects. In 1997 he became one of the first to take the National Council on Qualifications for the Lighting Profession (NCQLP)exam to become Lighting Certified (LC).