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The information contained on the following pages is excerpted from a comprehensive Ballfield Lighting Study prepared for the City of Seattle in 2001. DMD authored all technical portions of the report which included the attached discussion. This section of the report examines, in detail, the facts related to choosing lamp wattage for sports lighting projects. This issue became part of the study largely because a single consultant the City had used on past projects insisted that very large savings in life-cycle costs could be realized through the use of 1000-watt lamps. As you will see from our examination of the facts, we found this assumption to be untrue.

Our conclusions regarding this debate can be summarized in two short statements.

1. *Capital costs for installations with 1000-watt fixtures will be at least 30-percent or more over installations with 1500-watt fixtures. Typically costs will actually be higher, depending on project specifics such as foundation costs, installation labor, and other variables. Using 1500-watt fixtures will typically result in a cost saving of over $35,000 per lit field over 1000-watt fixtures.*

2. *There is no evidence that life-cycle cost savings from 1000-watt fixtures will recapture the additional capital costs incurred. In each case examined, use 1000-watt fixtures deliver less value to the owner.*

We believe that with the sports lighting industry's high demand for 1500-watt fixtures, the rated lamp life will improve over time as research and development improve the technology. This will make 1500-watt lamps even more cost effective. In fact, one lamp manufacturer has already developed a 1500-watt lamp for this purpose rated at 6000 hours. Additionally, in the course of our sports lighting practice, we have undertaken measurement of the lighting levels over time on a number of high usage fields which use the 1500-watt Phillips Z-Lamps (manufactured for Musco) and found their useful life to be far better than the published mortality and lamp depreciation factors used in our study.

Owners are advised to carefully examine maintenance strategies for sports lighting installations and become knowledgeable regarding the variables involved. This includes our strong recommendation that regular performance evaluations be undertaken by qualified specialists who can quantify when re-lamping is required.

Light Source Trends

An important debate continues in current sportsfield lighting design centered around defining the relative merits of 1000-watt metal halide versus 1500-watt metal halide lamps. Both 1000-watt and 1500-watt lamps are routinely used for sports lighting installations.

Clearly the biggest factor in the lamp debate is lamp life. Assembled below is lamp data from GE, Philips, Sylvania, and Venture. This lamp data is shown in Table 4 on below. From this table one can see that all lamps are different. The assembled data was based on recent available manufacturer's published information. However, this published data can be very deceiving. Lamps are designed and tested with orientation of the lamp base positioned up or down, horizontal or universal. Lamp suppliers submit published data of extended lamp life and lumen output for both vertical and horizontal orientation. Often the long-life lamps require a base up orientation (plus or minus 15 degrees) and, therefore, are not suitable for sports lighting installations. Sports lamps typically operate in a base-up to horizontal position with the arc tube of the lamp at an angled position.

Product	Operating Position	Rated Life at 5 Hour Starts	Initial Lumens	Bulb Type	Comments
1000-watt Sylvania M1000U	Universal	6750 hrs (H) 13,500 hours (V)	107,800 (H) 110,000 (V)	BT56	Use 6750 hours for sports lighting
1500-watt Sylvania M1500BUHOR	Base Up to Horizontal	3000 hours	153,000 (H) 158,000 (V)	BT56	
1000-watt Philips MH1000/BU	Universal	9000 hours	110,000	BT56	
1500-watt Philips MH15000/BU	Base Up to Horizontal	3000 hours	165,000	BT56	
1500-watt Philips Musco Z Lamp ***(See Note 1)***	Universal	3000 hours	155,000	BT56	
1000-watt GE MVR1000/U	Universal	6750 hours (H) 9000 hours (V)	96,600 (H) 105,000 (V)	BT56	Use 6750 hours for sports lighting
1500 GE MVR15000/HBU	Base Up to 15° Below Horizontal	3000 hours	146,000 (H) 155,000 (V)	BT56	
1000-watt Venture MS1000W/HOR/ SPORT 60	Horizontal ± 60°	9000 hours	115,000	BT56	
1500-watt Venture MH 1500W/U/XL	Universal	6000 hours	165,000	BT56	

- *Note 1 – Lamp made by Philips for Musco. Lamp has angled arc tube to reduce tilt factors.*
- *Note 2 – Where both horizontal and vertical positions are noted, the horizontal position shall be used.*

Table 4 – Vendor Lamp Life Data

The best lamp life performance is achieved if the lamp is allowed to burn for long periods without turning it on and off. The life of the 1000-watt lamp is rated at 10-hour operational periods, whereas the 1500-watt lamp rating is at five-hour operating periods. To calculate lamp life for 1000-watt lamps based on five-hour starts, a 75% derating factor is published by GE and Venture. When the 1000-watt lamp is derated for the five-hour start, its life is reduced from 9000 to 12,000 hours to approximately 6750 to 9000 hours.

Light output of all lamps depreciates with age. This is commonly referred to as lumen depreciation. When analyzed from the manufacturers' lumen maintenance curves, a 1000-watt metal halide lamp loses its light output much more quickly than a 1500-watt metal halide lamp as shown in Table 5 on the following page. It is critical that the on-field lighting levels should not be allowed to drop below the maintained levels specified by the designer.

The design lamp lumen depreciation (LLD) for metal halide is 0.8. A 1500-watt lamp loses approximately 18 percent of its total light output from depreciation over the course of its life, whereas a 1000-watt lamp loses 35 percent of its light output over its rated life. To preserve maintained levels as designed, the light output should not be allowed to drop below 20 percent (0.8) of its initial output. Based on published data, a 1000-watt lamp loses 20 percent of its lumen output at 40 percent of its rated life. Therefore, although the 1000-watt lamp is still burning, it no longer produces a sufficient amount of light to meet the recommended performance standards. Refer to Table 5 below.

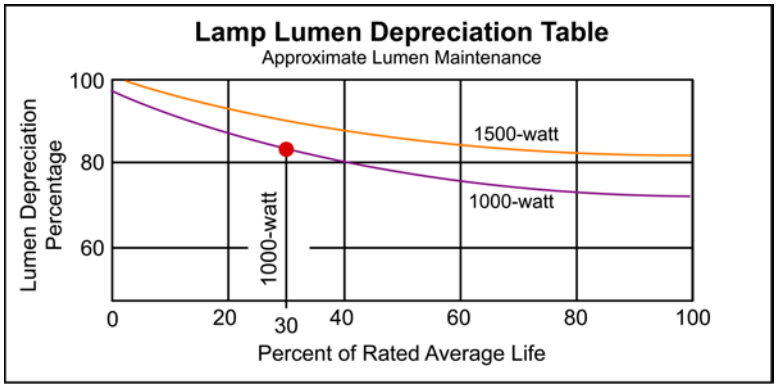

Table 5 – Lamp Lumen Depreciation (Philips)

Lamp mortality is another factor to be considered. Manufacturers express this in a lamp mortality curve that indicates the percentage of lamps which survive to operate over their rated life. The mortality curve is very similar for the 1000-watt and 1500-watt lamps. From Philips published data noted in Table 6 below, the lamp mortality is very high (approximately 55 percent) at 3000 hours for a 1500-watt lamp, and very low (approximately 5 percent) at 3100 hours for the 1000-watt lamp. On-field lamp mortality should not be allowed to deteriorate below 20 percent to maintain recommended performance standards. Entering Table 6 below at an 80 percent mortality factor, note that the 1500-watt lamp has a 70 percent (0.7) rated average life.

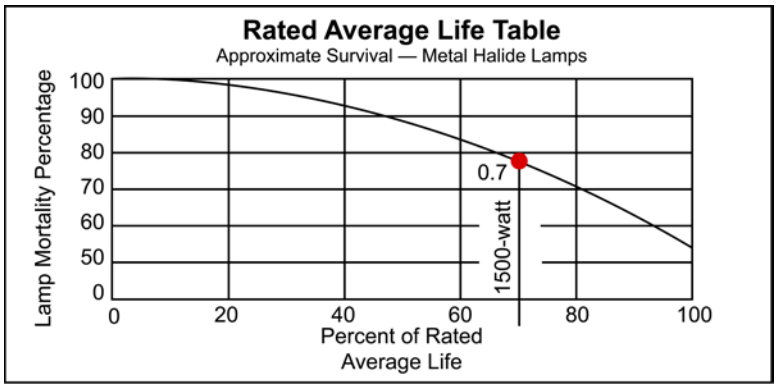

Table 6 – Rated Life Table (Philips)

Initial Lumens	1500-Watt Lamp	1000-Watt Lamp
Rated life at 5 hours of continuous operation	3000 hours	9000 hours
Rated life at 20 % lumen depreciation (5 hour starts) *see table no. 5*	3000 hours	3600 hours
Rated life considering 20 % lamp mortality *see table no. 6*	2100	3600
Initial Lumens	155,000	110,000
Lamp Cost	$70.00	$50.00

Information provided by Philips

Table 7 – Lamp Life Comparison

Lumen output, and in some cases the rated life, can vary considerably from supplier to supplier depending upon duration per start, lamp operating position and other factors. Lamp manufactures frequently unveil new products with long life claims and increased output; however, many are tested in varying operating conditions.

In the past, sports field lighting installations were primarily 1000-watt metal halide lamps. The recent trend, however, is toward 1500-watt fixtures with a minority of owners using 1000-watt luminaries and lamps.

Key issues to consider when choosing the lamp wattage include the following.

- **Capital Cost** – An installation with 1500-watt fixtures typically utilizes one third fewer fixtures, reducing capital cost of poles and fixtures approximately 33 percent. If one considers a cost of $1500 per fixture the increased capital cost would be approximately $30,000 for a typical field.

- **Power Costs** – Power consumed is nearly the same for 1000-watt or 1500-watt installations.

- **Re-Lamping Costs** – Refer to Table 8 on the following page for a case study of that evaluates lamp replacement cost of 1000-watt and 1500-watt for a typical soccer field.

We have undertaken a analysis of the equipment supply capital costs along with lamp replacement costs over a 20 year period. This analysis is shown in Table 8 on the following page. The equipment supply cost is based on a 30 fc soccer field installation using aimable sports lights.

Life Cycle Costs		
	1500-watt	**1000-watt**
Number of Luminaires	55	73
Estimated Capital Equipment Cost	$80,000	$110,000
Maintenance costs over 20 years		
a. number of total re-lamps based on 500 hours of usage per year	5	3
b. number of total re-lamps based on 1000 hours of usage per year	10	6
c. labor cost per re-lamp	$3800	$5000
d. lamp cost per re-lamp	$3850	$3650
Subtotal	**$7650**	**$8650**
e. total cost over 20 years, based on 500 hours per year	$38,250	$25,950
f. Total cost over 20 years, based on 1000 hours per year	$76,500	$51,900
Total life cycle (lamps and capital equipment costs)		
based on 500 hours per year	$118,250	$135,950
based on 1000 hours per year	$156,500	$161,900

Table 8 – Capital Installation and Lamp Replacement Costs