Retrofitting older growth chambers to improve PPF, electrical efficiency and uniformity

UtahStateUniversity
DEPARTMENT OF PLANTS, SOILS, & CLIMATE

March 2013

Jacob A. Nelson and Bruce Bugbee
Crop Physiology Laboratory, Utah State University, Logan, UT

Abstract

Recent federal legislation (The Energy Policy Act) has phased out the T12 VHO light that has long been the standard in many growth chambers. We analyzed options for retrofitting with the goal of improving uniformity, PPF, and electrical efficiency. Our findings indicate that retrofitting with vertical mount, open fixture, ceramic metal halide lamps achieves these attributes after a modification to the lamp to prevent hot spots.

We analyzed three light sources:

- T12 VHO fluorescent
- HPS/MH 1:1 mix
- Ceramic metal halide (CMH) tested vertically and horizontally

Chambers with VHO fluorescent lamps were the worst in all three categories. The HPS/MH mix provided improved efficiency and high PPF, but horizontal mounting did not improve uniformity. The CMH mounted vertically in a luminaire (Cycloptics All-Bright) provided similar PPF, much improved uniformity (after modifying the lamp) and double the efficiency.

	PPF			Efficiency				Uniformity					
	Average PPF			Input kWatt	Average PPF per kilowatt			µmol J	Max Min			Coefficient of Variation (%)		
	50*	80*	Avg		50	80	Avg	Avg	50	80	Avg	50	80	Avg
T12 VHO Fluorescent	600	469	535	3.08	195	152	174	0.25	1.70	1.48	1.59	12.7	8.9	10.8
HPS/MH Mix	1638	1352	1495	4.66	352	290	321	0.46	1.65	1.37	1.51	11.3	7.1	9.2
Ceramic Metal Halide														
Horizontal	1532	1178	1355	2.16	709	545	627	0.90	1.27	1.16	1.22	7.3	4.1	5.7
Vertical	1608	1201	1405	2.16	744	556	650	0.94	1.28	1.26	1.27	4.9	4.3	4.6
Vertical w/Painted Tips	1595	1161	1378	2.16	741	554	647	0.93	1.17	1.17	1.17	3.5	3.7	3.6

All measurements made after 300-h run time.
*Measurements made at 50 and 80 cm below lamps.
Coefficient of Variation = standard deviation/mean

T12 VHO Fluorescent- 16, 6 ft. VHO, cool white fluorescent tubes with 2, 18” tubes on each end in a Conviron E15 Chamber.

HPS/MH Mix- A standard Conviron PGR15 (same dimensions as an E15) chamber with the original mix of 5 High Pressure Sodium and 5 Metal Halide lamps mounted horizontally.

CMH Horizontal- 6 Ceramic Metal Halide lamps retrofitted into a Conviron E15 chamber below polished aluminum.

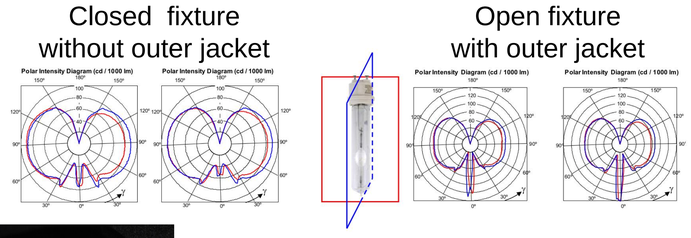
CMH Vertical- 6 Ceramic Metal Halide lamps in Cycloptics All-Bright luminaires, retrofitted into a Conviron E15 chamber.

CMH Vertical with Painted Tips- Same as above, but incorporating a painted tip to remove bright spots directly below the lamp.

Modifying the open fixture lamp to remove the hot spot

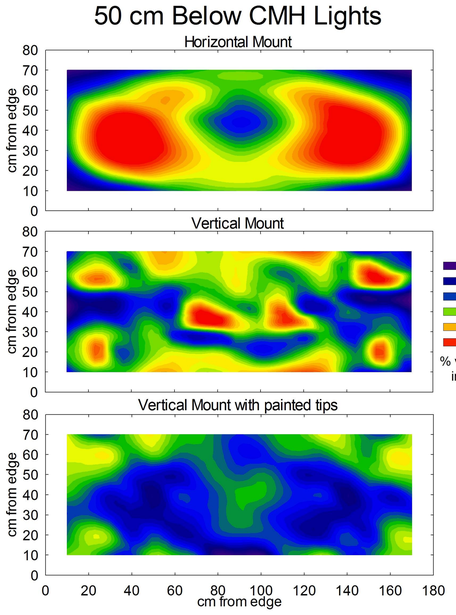
Closed fixture without outer jacket

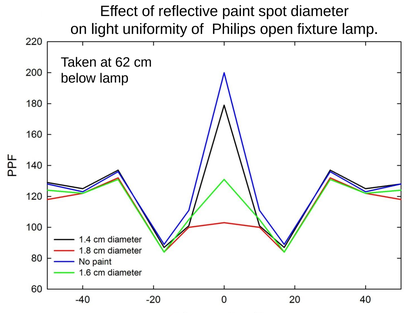
Open fixture with outer jacket



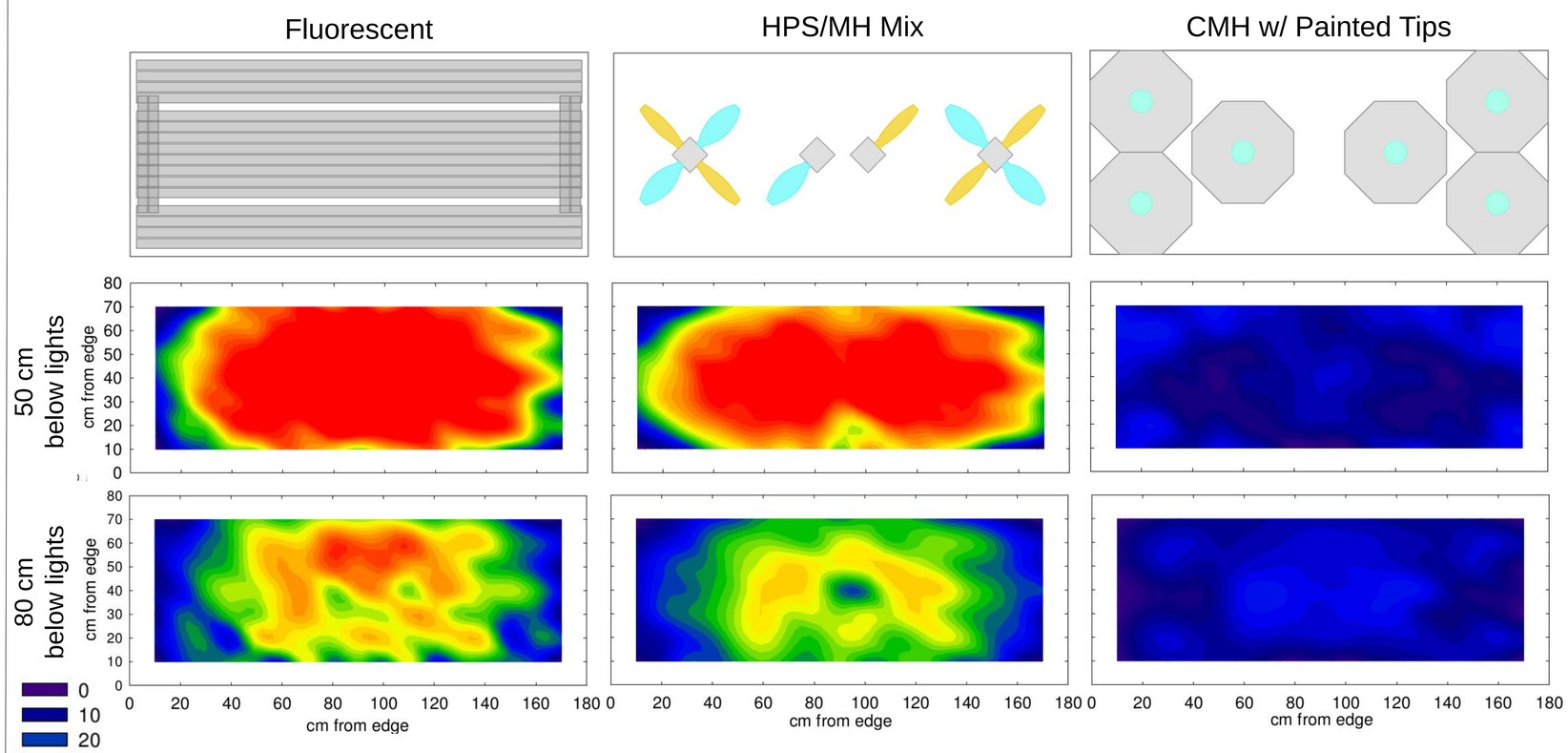
As seen above, the outer jacket of the Philips 315 W, Ceramic Metal Halide Lamp allows it to be mounted in open fixtures, but creates a spike of radiation directly below the tip of the bulb (Philips OEM Design Guide 2010). After analysis of several options, we used a 16 mm diameter spot of aluminum based paint on the tip of the lamp to eliminate the hot spot.

50 cm Below CMH Lights





Uniformity



Note scale from 0-50%

A step by step procedure for retrofitting a Conviron E15 chamber to CMH can be found at:
http://cpl.usu.edu/files/publications/factsheet/pub__3626113.pdf

cpl.usu.edu