Horticultural Lighting

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BIO

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• Lighting Engineer 2004 – 2013
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Agenda

• Horticultural Market Overview
• UL 8800, Outline of Investigation for Horticultural Lighting Equipment
• Differences between UL 1598 and UL 8800
• Photometrics
• System Security
Horti Market Overview
Indoor Growing and Vertical Farming: Trends

• **Over the next few decades:**
  - The world’s population will grow dramatically
  - Larger percentages of the population will live in cities
  - Availability of productive open farm land will be limited
  - Increased food production will be needed for the growing population
  - Increased plant production used for medical purposes will be needed

• **Growers and other interest groups** are investing heavily in indoor growing solutions to meet these future needs
Indoor Growing and Vertical Farming - Benefits

• **Indoor Growing:**
  - Controlled environmental conditions results in healthier yield
  - Fewer plants lost to disease, bugs and animals
  - Faster cycle time from seedling to maturity
  - Reduced amounts of chemicals needed over complete plant cycle
  - Lower levels of water consumption due to reduced evaporation

• **Vertical Farming:**
  - Same benefits as indoor growing plus greater production levels per square foot of growing space
Indoor Growing and Vertical Farming – Role of Lighting Equipment

• **Lighting Equipment is the key ingredient to the success of this industry**
  
  - Lighting Equipment can be designed to produce those wavelengths of light produced by the sun important for plant growth
  
  - Can be used to supplement light from the sun or be the sole source of light for the plants where sun is not present
  
  - Most common light source types are HID and LED…Others include Fluorescent, LEP and Induction
  
  - LED technology has several advantages over others…less heat, direct/narrow light source, tunable spectral output opportunities. Can be located closer to plants, conducive to vertical farming applications
Horticultural Lighting: Environmental Conditions and Installation Methods

• **Environment:**
  - Higher ambient temperature conditions
  - Higher levels of Humidity
  - Higher levels of dirt and dust
  - Equipment potentially exposed to water spray or wash-down conditions
  - Equipment’s polymeric materials may be exposed to UV rays from the sun or from the light output of the equipment
  - Possible exposure to chemicals

• **Installation:**
  - Often rack mounted or chain and cable mounted
  - Frequently moved or height adjusted
  - Common use of cords, plugs and connectors for electrical connections
  - Light source closer workers in the environment
UL 8800 and Certification
Why UL 8800?

Historically, horticultural lighting equipment has been evaluated using safety requirements established for general lighting equipment and have been Certified under general lighting categories.

The different spectral characteristics, different operating environment and different installation methods call for the need for this equipment to have its own identity and separate and distinct safety requirements.
UL’s Safety Certification – UL 8800

UL 8800
Outline of Investigation for Horticultural Lighting Equipment

Issue Number: 1

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Summary of Topics
This first issue of the Outline of Investigation for Horticultural Lighting Equipment, UL 8800, covers lighting equipment intended for use in a horticultural environment and installed in accordance with the National Electrical Code (NEC), ANSI/NFPA 70.

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UL’s Safety Certification – UL 8800

1 Scope

1.1 The requirements contained in this outline of investigation apply to lighting equipment intended for use in a horticultural environment and installed in accordance with the National Electrical Code (NEC), ANSI/NFPA 70.

1.2 Equipment covered by this outline of investigation is intended for horticultural lighting purposes and includes: luminaires, lampholders, wire harnesses, plugs and connectors, LED packages, ballasts/LED drivers, lamps, and hardware and structures associated with optimizing light for growing.

1.3 Lighting equipment that provides broadband white light such as light for general illumination, or whose primary purpose when applied to plantings is aesthetic and/or sustaining plant life is not considered horticultural lighting.
UL’s Safety Certification Program

- Two Certification categories (CCN’s) created for Horticultural Lighting Equipment:
  - Provides manufacturers the opportunity to distinguish their Lighting equipment for Horticultural use from general lighting equipment
  - For the U.S., IFAU - Horticultural Lighting Equipment
  - For Canada, IFAU7 – Horticultural Lighting Equipment Certified for Canada
  - Equipment certified under these CCN’s are marked “Horticultural Lighting Equipment”.
UL’s Safety Certification Program

• **UL 8800 :**
  - Construction requirements and tests contained within **UL 8800** - **UL’s Outline of Investigation for Horticultural Lighting Equipment.**
  - Published on May 4, 2017
  - Next step to develop into a Standard

• **Includes Safety requirements for:**
  - Installation instructions
  - Environmental ratings – temperature, humidity, water and dust
  - Eye safety considerations (photobiological safety evaluation)
  - Polymeric materials (UV rated)
  - Electrical connections- Cords and plugs
Key Differences
Polymeric Materials

**UL 1589 - Luminaires**
- Minimum 5VA flammability rating
- Temperature
- Impact test
- Mold stress-relief test of Clause 16.4 for molded or formed thermoplastic material;
- Resistant to UV radiation where the material is exposed to the sun or to fluorescent or unjacketed metal halide light sources

**UL 8800 – Horticultural Lighting**
- Polymeric material exposed to the sun or to a light source emitting UV-A or UV-B radiation and necessary for the protection against electric shock, fire, or casualty hazard, shall not degrade such that it no longer performs its intended function.
**Power Cords**

**UL 1598 – Luminaires**

- A fluorescent or HID pendant luminaire designed for a chain, hook, or similar means of suspension may be provided with a flexible power cord.
- A luminaire that can be adjusted, after installation, to change the angle of light shall be provided with one of the following:
  - a cord bushing and a length of flexible cord of hard-usage type or heavier for connection to branch circuit conductors; or
  - a junction box cord grip bushing without a length of flexible cord.

**UL 8800 – Horticultural Lighting**

- Provisions for connection of conduit or other permanent wiring method
- A length of a flexible cord,
- A length of flexible cord with an assembled-on plug having a NEMA configuration,
- A power supply cord (length of flexible cord with a molded-on plug) having a NEMA configuration, or
- Provisions for a proprietary wiring system (harness).
Environmental Ratings

**UL 1598 – Luminaires**
- Dry
- Damp
- Wet

**UL 8800 – Horticultural Lighting**
- Damp
- Wet
- IP Ratings, min IP54
Photobiological Safety

**UL 1598 – Luminaires**

**UL 8800 – Horticultural Lighting**

- Subjected to a photobiological safety assessment across the wavelength range from 280 nm through 1400 nm in accordance with the requirements in the Standard for Photobiological Safety of Lamps and Lamp Systems, IEC 62471

- Risk Group 0 (Exempt), Risk Group 1, or Risk Group 2. Risk Group 3 is not permitted

- Markings
Photometrics
Plants Don’t Have Eyes!
Horticultural Lighting: Technologies

Traditional Plant Growth Lighting:
• The Sun
• High Pressure Sodium
• Metal Halide
• Fluorescent

Newer Technologies of Plant Growth Lighting:
• Ceramic Metal Halide
• Plasma
• Induction
• **Light Emitting Diodes**
Horticultural Lighting: Metrics

• Familiar metrics are all geared towards the human eye response
  – Lumens, Candela, Lux, CCT, CRI
• Human eye response is focused in the green and yellow areas, drops off for red and blue

• Plants absorb radiation through photosynthesis
  – And other mechanisms
• Photosynthetic radiation absorbs strongly in the deep blue and red spectrums
  – But not only in these spectrums
Horticultural Lighting: Metrics and Methods

Who Defines Metrics and Methods?

- American Society for Agricultural and Biological Engineering (ASABE)
- 3 working groups in process for documents to help
- Documents are in development for general plant growth:
  - Definition and Metrics
    - Important for any discussions on lighting performance
  - Test Method
    - Important to ensure performance claims are consistent comparisons
  - Performance Standards
    - Collection of requirements
Horticultural Lighting: Notable Metrics

- **Photosynthetically Active Radiation (PAR)** – Already a common metric in horticulture, considers radiation that is used for photosynthesis, from 400 to 700 nm, in Watts
- **Photosynthetic Photon Flux Density (PPFD)** – PAR photon rate per unit area on a surface
- **Daily Light Integral** – PPFD integrated over a 24 hour period, influenced by operating time
- **Far-Red range** – light in the 700 nm to 800 nm range
- **UV range** – light in the 100 nm to 400 nm range
  - Realistically, UV-C is largely filtered out from sunlight by the atmosphere, so the general area of interest is 280 nm to 400 nm
- **Spectral Power Distribution** – Not a single metric, but illustrates where a product produces lighting, useful for photomorphology
When looking for performance testing, consider use conditions:

• **Heat**
  - Plants grow better when it is warm
  - LEDs tend to decrease in intensity with heat
  - May cause spectrum shift

• **Humidity**
  - Plants require water, and will give off humidity
  - High humidity and heat may impact thermal conditions of LEDs

• **Distance from Plants**
  - When intensity (PPFD) metrics are given, what distance is quoted and is it appropriate for the use?
  - How even is the distribution?
Horticultural Lighting: Performance Test Methods

• Current List of Horticulture Oriented Lighting Test Methods:
  - ...
  - ...

• Test Methods that are being used for Horticultural Lighting:
  • IES LM-79:
    - Oriented towards photometric measures
    - Test conditions not realistic for horticulture
  • IES LM-80
    - Rarely is the LM-80 available for direct color LEDs used in horticulture
  • IES TM-21
    - Designed with phosphor converted LEDs
  • UL 1598
    - Designed for many use scenarios
    - Not designed with horticulture in mind
Horticultural Lighting: Regulations

Current Regulations:

• **U.S. Department of Energy:**
  - Exemptions exist on regulated lamps for plant growth lighting

• **California Title 24:**
  - 140.6 - Lighting wattage excluded:
  - (G) Lighting for Plant Growth or Maintenance, if it is controlled by a multi-level astronomical time-switch control that complies with applicable provisions of Section 110.9

• **ASHRAE 90.1:**
  - 9.2.2.3 Interior Lighting Power
  - Lighting for Plant Growth or Maintenance is exempt…
    • If controlled by an independent control device

• **IECC 2015**
  - Lighting for Plant Growth or Maintenance exempt
Horticultural Lighting: Programs

• DesignLights Consortium:
  - Held discussions on Horticultural lighting in 2015 DLC Meeting
  - 2 Horticulture sessions on the schedule for 2017 DLC Meeting
  - Representatives participating in the ASABE efforts
  - Expect to see Horticultural Lighting included in the DLC in the future

• ENERGY STAR:
  - Evaluated the potential for a horticultural specification
  - Has not taken action
    • Program focus is on residential applications
    • Most horticultural lighting is commercially oriented

• US Department of Agriculture
  - In past has provided funds to upgrade to LED Lighting
  - Rural Energy for America Program
    • Efficient lighting is one of the potential grant and loan programs
What To Look For: Horticultural LED Products

Different Environment, Different Metrics, Different Specifications…

• What is the performance?
  - Are horticultural metrics used?
  - Are the tested conditions realistic to use?
  - How uniform is the distribution?
  - Is the spectrum what your plants need?
  - Is it better than the incumbent technology for your application?

• What is the durability and lifetime?
  - Are lifetime calculations at true operating temperatures?
  - How will it resist moisture?
  - Can the fixture be used for multiple crops?
Making Plants Grow

The main properties of light that make the plant grow well/flower:

**Light quantity / intensity:**
The growth of a plant is strongly determined by the total number of photons that it absorbs in the PAR region. In winter there is often too little natural light for plants to grow and continue to produce good flowers and fruits.

**Day length:**
With many plants, the time of flowering is influenced by the photoperiod. For example, a chrysanthemum plant will only bloom when the night is long. We call them ‘short day plants’. However when you apply long day light to them, the flowering will be suppressed.

**Spectrum:**
The mix of colors in the light (spectrum) also strongly influences the development of a plant. Light uniformity When using artificial lighting, uniformity and constant quality of the light spectrum is very important for a constant quality of crop production.
Light Recipes

Different plants grow based on different types of light inputs

Plants may need different types of light at different stages in their development

Plants may need different types of light at times of the day
System Security
70% of IoT devices are vulnerable to attack (Source: HP)

By 2018, 66% of networks will have experienced an IoT security breach (Source: IDC Research)

28% to 47% of organizations have experienced IoT-related breaches (Source: Forrester/CISCO)

In 2016, the average consolidated total cost of a data breach was $4M USD (Source: 2016 Ponemon Study)
Cybersecurity Solutions: UL 2900-1

Network-Connectable Products & Systems

- Automotive
- Lighting
- Appliances
- Smart Home
- HVAC
- Building Automation
- Alarm Systems
- Smart Meters
- Medical Devices
- Fire Systems
- Industrial Control Systems
- IoT

YOUR NETWORK CONNECTABLE PRODUCT AND/OR SYSTEM

Submit product or system for discrete testing (One or more individual tests)

Submit product or system for certification testing (All tests)

Cybersecurity Solutions

Testing Services

- Fuzz Testing
- Known Vulnerabilities
- Code & Binary Analysis
- Access Control & Authentication
- Cryptography
- Remote Communication
- Software Updates
- Structured Penetration Testing

Training Services

Advisory Services

Review Services

YOUR REPORT AND/OR CERTIFICATION

Test Report

Certificate

Key Takeaways:

- Risk Mitigation
- Innovation
- Competitive Advantage
Fuzz Testing
A technique used to discover coding errors and security loopholes in software, operating systems, or networks by inputting massive amounts of random data, called fuzz, in an attempt to make the device operate improperly.

Tools Used:
- Synopsys Codenomicon
- Defensics
- American Fuzzy Lop (Open Source)
Known Vulnerability
A known vulnerability if a vulnerability listed in the National Vulnerability Database (NVD).
https://nvd.nist.gov

• Provides an ability to identify the software supply chain

SOFTWARE BILL OF MATERIALS
Source of the software:
• In-house development
• Third-party library
• Open source
• Snippets of open source

Tools used:
• Synopsys Protecode SC
Structured Penetration Testing

A software attack on a computer system that looks for security weaknesses, potentially gaining access to the computer's features and data. The process typically identifies the target systems and a particular goal, then reviews available information and undertakes various means to attain the goal.

NOTE:
Penetration test will always be customized and structured to the specific product being tested as it is dependent on all the previous testing (CWE’s and CVEs) and the risk assessment.

Tools Used:
• Rapid 7 Nexpose
• Rapid 7 Metasploit Pro
• Rapid 7 AppSpider
• BurpSuite
• Open Source Tools
  – Kali Linux
  – OpenVAS
  – Other
Questions ?
THANK YOU.