NRC Construction

Light Source Flicker: What We Need to Know, and Why You Should Care

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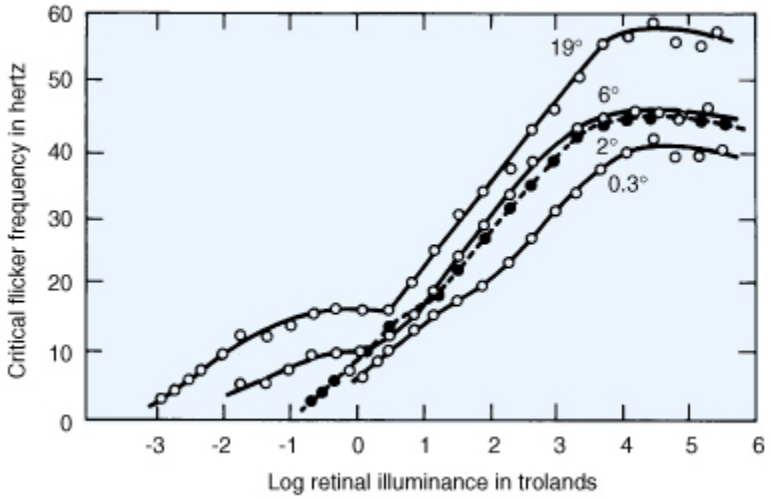
Definitions

- Sensation
- Perception
  - Critical flicker fusion [critical flicker frequency, critical fusion frequency] (CFF)

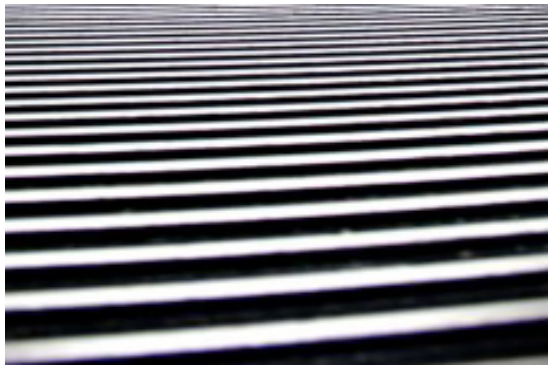


Source: *The IESNA Lighting Handbook: Reference & Application* (9th Ed.), 2000, p. 3-20

- Health - World Health Organization (1947):
  - …a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity”

Flicker Effects 1

- Photosensitive epilepsy
  - Short exposure to 3 – 70 Hz flicker (i.e., visible modulation) may cause seizures in sensitive people
  - Also static repetitive geometric patterns, like this photo of an escalator stair tread
  - 1 in 4000 people
  - Onset around puberty; 75% remain sensitive for life

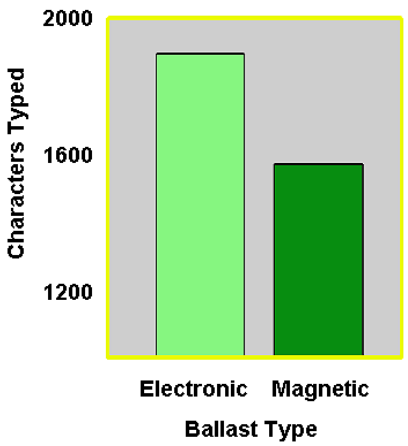


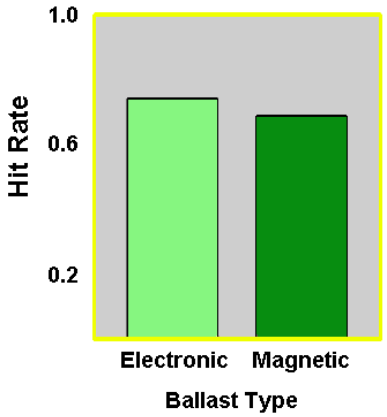
Flicker Effects 2

- Malaise: headache and eyestrain
  - Slower onset, to frequencies in range 100-120 Hz have been demonstrated
  - Exact population frequency isn't known; not everyone is affected

Flicker Effects 3

- Visual performance
  - Longer exposures to 100-120 Hz modulation, (i.e., not perceived as flicker) have been shown to reduce group average performance on visual tasks, both when viewed on paper and on CRT screens.





Source: Veitch, J. A., & Newsham, G. R. (1998). Lighting quality and energy-efficiency effects on task performance, mood, health, satisfaction and comfort. *Journal of the Illuminating Engineering Society, 27(1), 107-129.*

Flicker Problem 1

- Why is there a potential problem, if I (or my clients) can't say the light is flickering?
  - Some effects develop after
    - several minutes of exposure
    - to modulation above the CFF but **low enough in frequency for the nervous system's ability to respond**
    - by people who are sensitive to it.

Flicker Problem 2

- Does it matter what light source produces the flicker?
  - The characteristics of the physical stimulus matter, not its source:
    - Frequency and amplitude of modulation
    - Spectral (chromatic) variation
    - Adaptation luminance (higher luminance ↑ risk)
    - Contrast
    - Size of retinal area being stimulated
    - Distance to source and its location in the visual field (central stimulation ↑ risk)

Flicker Problem 3

- Is this only a problem for general room lighting?
  - Room lighting will cover a larger area of the visual field than some applications
  - …but, consider the nature of the visual task, e.g.,
    - a computer monitor taking up the whole visual field
    - the apparent flicker that arises from moving past a series of point sources (e.g., tunnel)

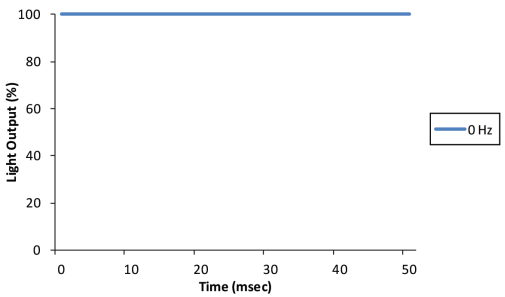
Flicker Information Gaps

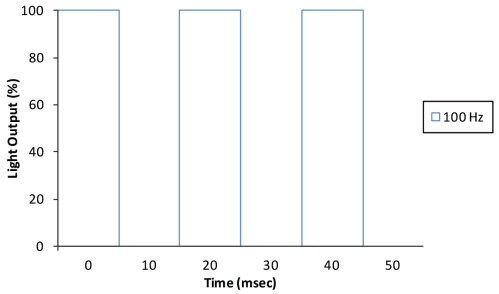
- Frequencies between 120 and 40,000 Hz
- Modulation depth
  - New metrics, or choose from existing?
- Chromatic effects
- At-risk populations
- Range of neural and behavioural outcomes

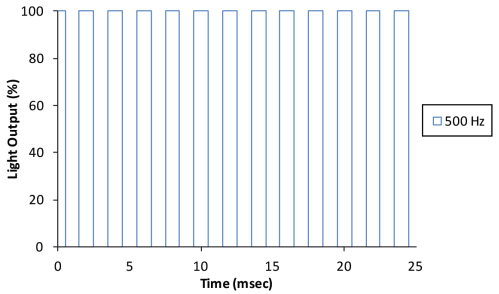
IEEE P1789 Recommended Practice

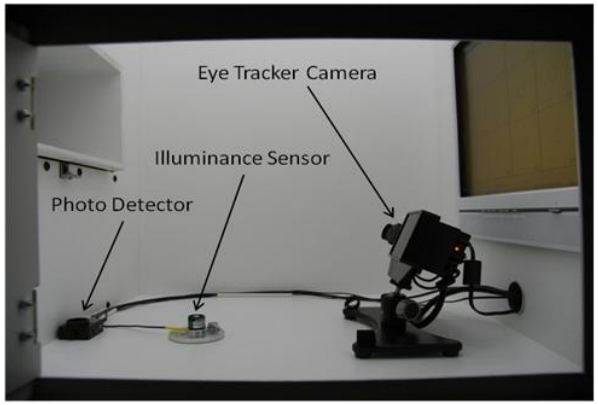
- Chair: Brad Lehman, Northeastern University
- Writing guidance document on LED flicker: "Recommended Practices of Modulating Current in High Brightness LEDs for Mitigating Health Risks to Viewers"
- Recommendations based on risk analysis: probability of adverse outcome x severity of outcome

NRC & Collaborators' Experiment









Why this matters…

- Avoid adverse outcomes:
  - Health & behavioural problems for users & employers
  - Market acceptance:
    - Popular opinion about fluorescent lighting
    - The CFL experience
  - Cost to correct problems later

- Potential positive benefits
  - Find a range where performance is better?

For more information…

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