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Type B TLEDs Chosen by many, prohibited by some

Type B TLEDs represent a technology that some (e.g., schools) fully embrace while others (e.g., the U.S. General Services Administration [GSA]) do not allow. Pacific Northwest National Laboratory (PNNL) researchers have spent the past year trying to understand the lagging adoption of LED technology in the education sector through conversations with more than 30 K–12 school facility personnel. As we took the time to learn about the challenges schools face when considering a lighting upgrade, we began to understand why Type B TLEDs are so popular: with no driver and ballast, the Type B TLED offers convenience, simplicity and affordability. However, Type Bs also come with downsides: safety concerns and flicker.

While PNNL was learning more about TLED installations in the field, unbeknownst to us, GSA was in the process of revising its stance on Type B TLEDs. GSA owns and leases over 363 million sq ft of space and publishes its *Facility Standards for the Public Buildings Service* (P100) performance criteria for GSA-owned buildings. The 2024 version of P100 guidance states, "Type B retrofits with sockets powered by line voltage will not be utilized."

GSA's rationale for this change is multifaceted. First, there are limitations with lighting controls, potentially requiring a communication wire. Additionally, some Type B TLEDs are single-ended, while others are double-ended like their fluorescent predecessor. The labeling on the fixture may not be enough to prevent the inadvertent installation of a lamp other than Type B, leading to a larger safety issue. Another concern is the possibility of shock with 277 volts at the tombstone.

GSA's safety concern related to the wrong lamp being installed recently became reality at PNNL. Currently, both Type A and Type B TLEDs can be found across the PNNL building complex. In 2023, a TLED overheated and then dangled from the fixture after a well-trained technician made an understandable mistake installing the wrong TLED type. The fixture was wired for Type A, but Type B was put into the socket. This situation could have been much worse had the fixture been wired for Type B with Type A installed—an occurrence that is easy to imagine as more TLEDs are put in place. Schools may be particularly ripe for issues with TLEDs as most have very limited maintenance budgets and personnel, with cleaning staff often responsible for switching out lamps.

Beyond the electrical and physical safety, GSA P100 also states that "LED products must have a 'low risk' level of flicker (light modulation) through compliance with recognized standards such as IEEE Standard 1789-2015 [*IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers*] or NEMA 77-2017 [*Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria*]." Flicker was on our radar as we visited schools across the U.S. At a subset of schools, PNNL measured temporal light modulation (TLM) and found considerable reason for concern, particularly with Type B lamps: many systems would not comply with IEEE 1789 or other standards, exhibiting TLM equal to or worse than magnetically ballasted fluorescent systems, which were widely derided and linked to headache and eyestrain until they were slowly replaced with electronically ballasted systems in the 1990s. What those new ballasts solved was unfortunately reintroduced by some LEDs.

> "Of the 28 products tested, 22 had flicker characteristics that were equal to or worse than the magnetically ballasted T12s

While our own measurements were revealing, another report came in from a contractor who was concerned about flicker in the schools. The Type B TLEDs being installed in schools he was assisting all had considerable flicker, worse even than magnetically ballasted fluorescent lamps.

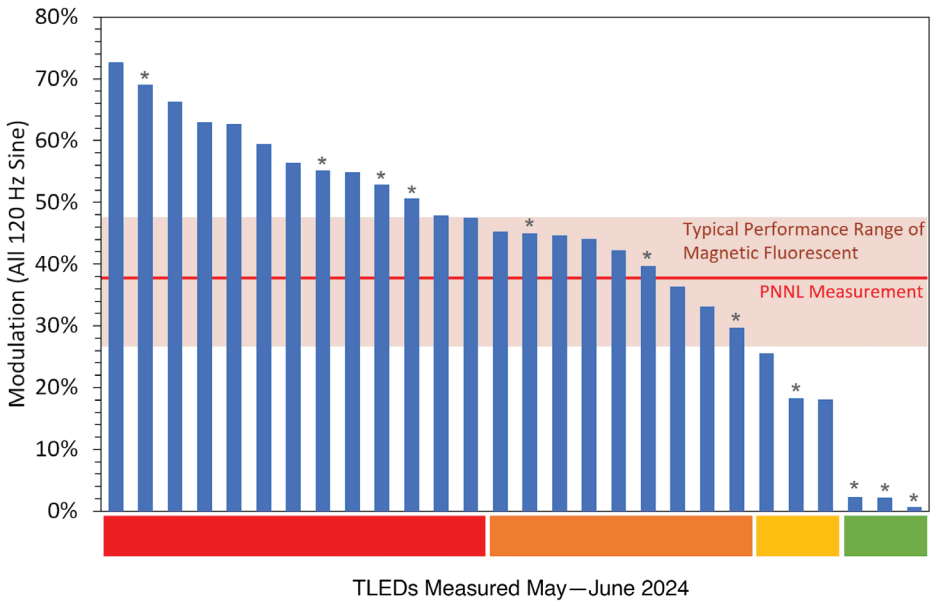

Figure 1. TLM of 28 typical TLED products from 26 manufacturers and a magnetically ballasted T12 system. The gray asterisk indicates a product that made a claim of low or no flicker. The orange, yellow and green align with the TM-39 performance tiers (minimum to potentially problematic, good and better). Red is outside the range of TM-39 performance tiers.

Given the growing concern over Type B TLEDs, PNNL decided to do a deeper dive. TLM was measured for 28 typical TLED products from 26 manufacturers as well as a magnetically ballasted T12 system. **Figure 1** summarizes the measurements. Of the 28 products tested, 22 had flicker characteristics (stroboscopic visibility measure and percent flicker) that were equal to or worse than the magnetically ballasted T12s (all were nominally 120-Hz modulation). What's perhaps even more disconcerting is that many products with very high levels of modulation were marketed as having little or none, sometimes even explicitly being labeled as *not like fluorescent lamps*.

While we find it disappointing to see so many products with quality characteristics worse than technology from the 1980s, some TLEDs were able to achieve low modulation, at least during initial operation. It remains unknown if the good performance will persist, as there are accounts of flicker characteristics worsening within less than a year of operation. With that in mind, PNNL is completing some long-term testing to better understand potential degradation over time.

One challenge facing lighting specifiers, including schools, is that TLM is infrequently measured and rarely reported in specification sheets or marketing material. Furthermore, there is confusing and conflicting guidance on what constitutes acceptable performance. IES committees are actively working on both fronts: IES LM-90: *Measurement of Temporal Light Modulation (TLM) of Light Sources* is being updated to address current knowledge, and IES TM-39: *Quantification and Specification of Flicker* is in the final stages before publication. TM-39 will introduce three performance tiers (minimum to potentially problematic, good and better) that address all visible aspects of TLM (direct flicker, stroboscopic effects and phantom arrays). Other information that is still needed is better understanding of the negative consequences of flicker beyond visibility and annoyance. PNNL is partnering with NEMA manufacturers and school districts to gather additional evidence on how flicker contributes to headache and eyestrain for teachers, as well as repetitive behaviors for autistic students.

LEDs have the potential to provide low-cost, high-efficacy, high-quality lighting for schools, offices and other applications where fluorescent lamps have dominated. But as we see with Type B TLEDs, the current risk is that the quality leg is suffering due to commoditization. Our hope is that spreading knowledge and introducing voluntary standards can help ensure lighting is safe and supports well-being for all. This way, the next time we tour schools, there's nothing but praise for how LEDs are a vast improvement.

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