Topic 18

Comparison of Three Generations of Industrial LED Lighting Technologies

First Generation (G1)

Structure:

• LED driver is installed inside the junction box, very close to the LED emitter.

• Two high heat sources (driver and LED) create thermal interference (thermal resonance).

Issues and Risks:

• Dual high-temperature zones cause severe thermal runaway.

• Forward voltage of LEDs decreases as temperature rises, leading to increased current, higher temperature, and accelerated failure.

• Even with constant current drivers, rapid thermal breakdown occurs due to resonance.

Typical Operating Temperature Range: ~–40°C to 45°C.

Second Generation (G2)

Structural Improvement:

• Driver mounted vertically to reduce proximity to LED heat source.

Benefits and Limitations:

• Slightly increased thermal resistance (+5°C).

• Still based on traditional separation but optimized spatial arrangement.

Typical Operating Temperature Range: ~–40°C to (50)~60°C (must reduce rating at higher wattages).

Third Generation (G3)

Core Technology: Fully Solid-State Driver-on-Board (DOB)

Structural and Material Innovations:

• COB architecture integrates LED and driver on reflective metal board.

• Gold wire bonding connects all components.

• In-house phosphor formulation for industrial applications.

• Stress-free packaging enables –80°C to +200°C range.

Electrical Features:

• Input voltage from 12VAC to 600VAC RMS.

• Surge protection: up to 15kV (module) and 30kV (entire fixture).

• No flicker, no inrush current; suitable for parallel operation.

Typical Operating Temperature Range: –80°C to 115°C, some models tested stable at 125–145°C.

G1

Typical Operating Temperature Range: ~-40°C to 45°C.

G2

Typical Operating Temperature Range: ~-40°C to (50)~60°C (must reduce rating at higher wattages).

G3

TTL (Touch-the-Limit)
ParagonLED inside

Typical Operating Temperature Range: -80°C to 115°C, some models tested stable at 125~145°C.

Conclusion: Worker Safety and Suitability Principle in High-Temperature Industrial Lighting

At the heart of industrial fire safety is not only compliance with codes, but also the protection of workers, the security of industrial facilities, and the prevention of catastrophic losses. Adequate lighting is essential for safe working conditions, and when luminaires are improperly rated for high-temperature environments, they become a direct threat—not just to equipment reliability, but to human life and workplace safety.

The National Fire Protection Association (NFPA) has long established the principle of suitability: under NFPA 70 (NEC) and NFPA 101, electrical equipment must be suitable for the actual conditions of use, including the ambient temperature of the installation site.

In environments exceeding 65 °C (149 °F), installing luminaires rated only for 55 °C (131 °F) violates this principle. Such practices compromise fire safety, expose workers to unnecessary risks, and create liability issues that extend beyond the plant to insurance providers and regulatory agencies.

While housing LED drivers inside metal junction boxes can suppress open flames, this also accelerates degradation and short-circuit failures, which propagate into factory power systems, causing blackouts and potential fires. Remote driver architectures, though sometimes applied in sub-100 W fixtures, carry risks of voltage drop, cable overheating, and DC arc hazards that are more dangerous than AC faults.

Key Directive for Fire Safety Enforcement

Protecting workers and facilities requires strict adherence to the suitability principle. Equipment rated only for 55 °C must not be considered suitable in environments above 65 °C. Facilities operating in such conditions must adopt luminaires specifically designed and rated for ≥105 °C (221 °F) service, ensuring compliance with NFPA standards, OSHA workplace safety rules, and insurance requirements.