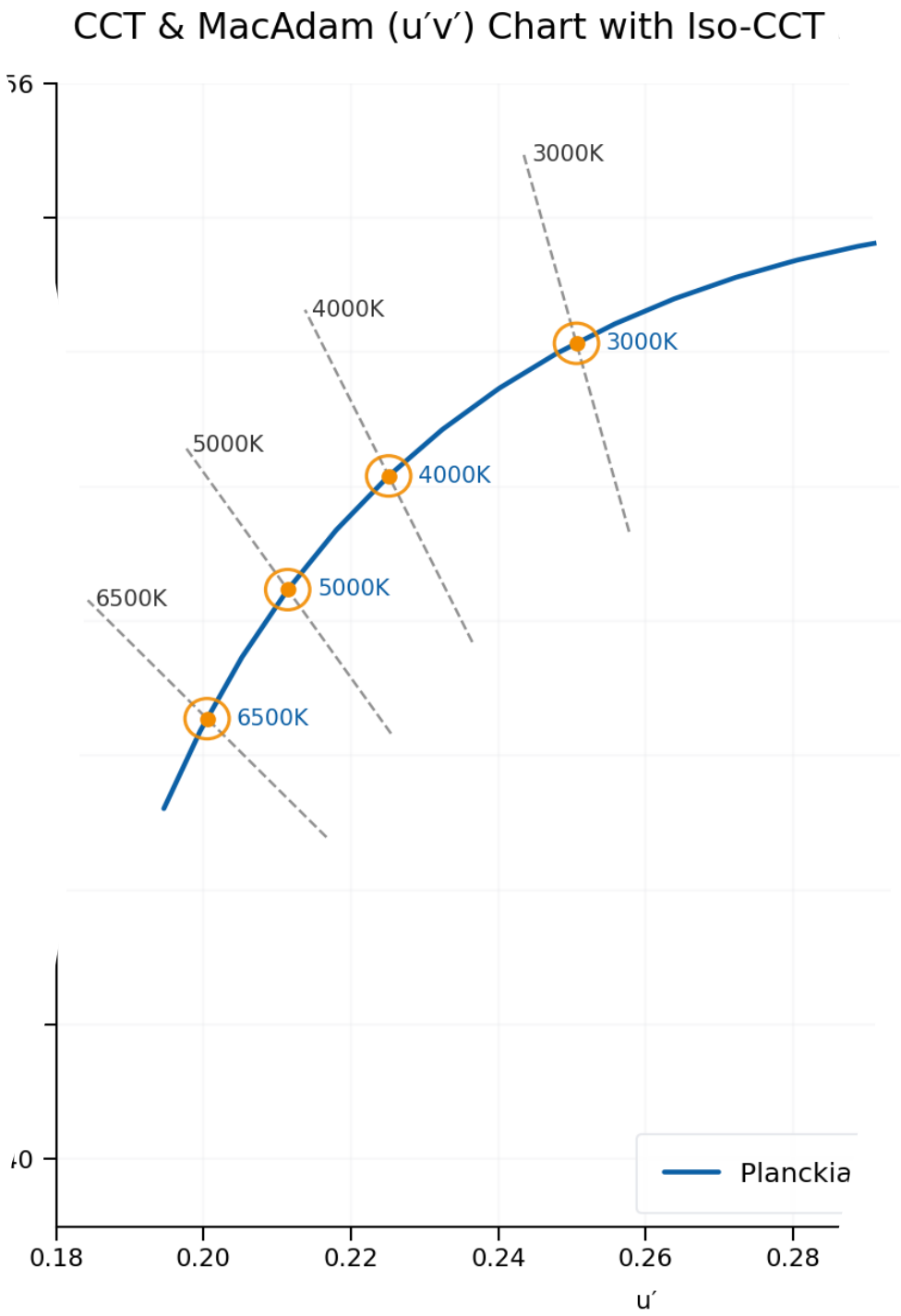
LED Fundamentals

- **What an LED Is & How It Works**
- LED = *Light Emitting Diode*, a semiconductor device
- Light is produced when electrons recombine with holes, releasing photons
- No filament → higher efficiency, longer life, and better reliability
- Color depends on semiconductor materials and wavelength control
- White light is created using:
  - Blue LED + yellow phosphor
  - RGB mixing
  - Violet LED + phosphors

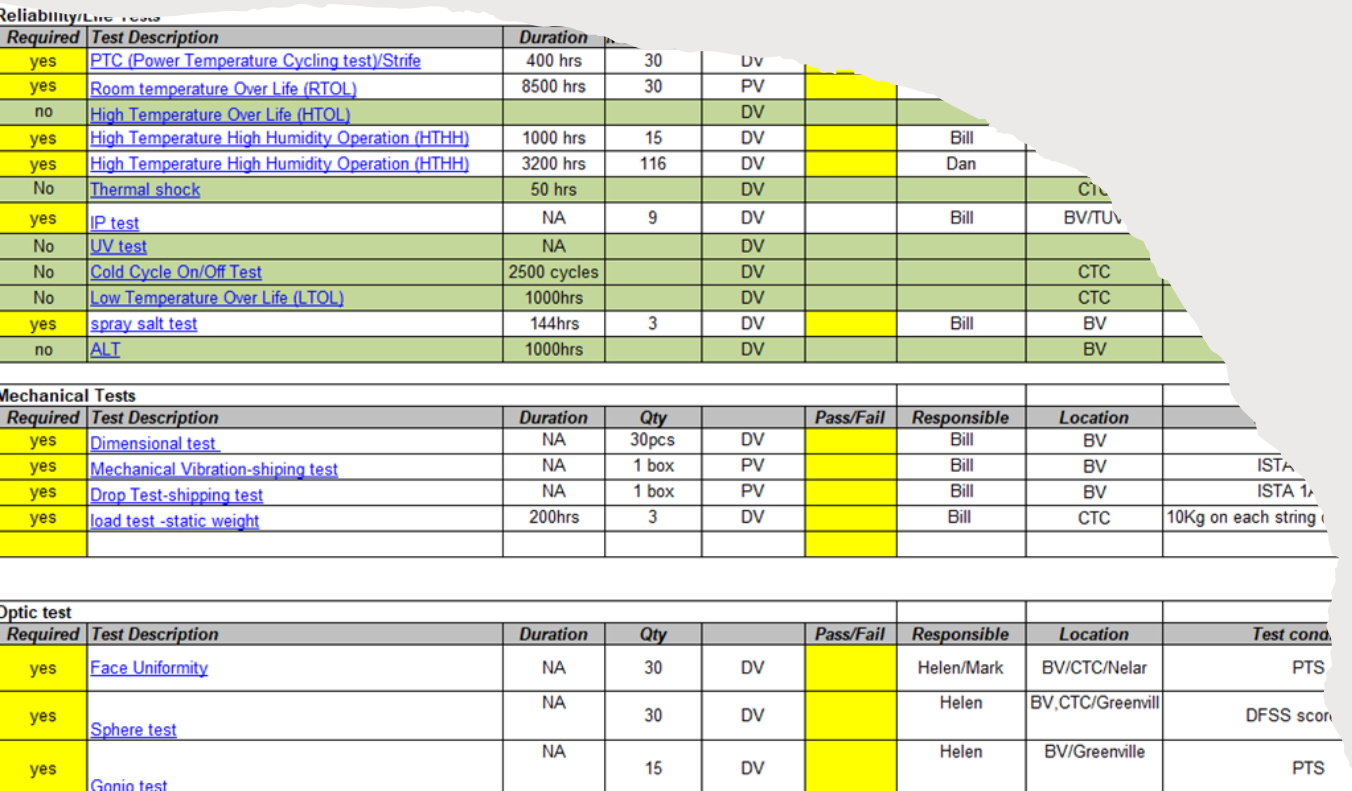
Performance, Measurement & Quality



How LEDs Are Evaluated

- **Key photometric terms**
  - Luminous Flux (lumens) – total light output
  - Luminous Intensity (candela) – directional output
  - Illuminance (lux) – light on a surface
  - Luminance (nits) – perceived brightness
- **Color consistency**
  - Controlled via binning and MacAdam ellipses
- **Industry standards**
  - LM-79: electrical & photometric performance
  - LM-80: lumen maintenance over time
  - TM-21: lifetime projection using LM-80 data

System Design & Reliability



Reliability/Life Tests

Required	Test Description	Duration						
yes	PTC (Power Temperature Cycling test)/Strife	400 hrs	30	DV				
yes	Room temperature Over Life (RTOL)	8500 hrs	30	PV				
no	High Temperature Over Life (HTOL)			DV				
yes	High Temperature High Humidity Operation (HTHH)	1000 hrs	15	DV		Bill		
yes	High Temperature High Humidity Operation (HTHH)	3200 hrs	116	DV		Dan		
No	Thermal shock	50 hrs		DV			CTC	
yes	IP test	NA	9	DV		Bill	BV/TUV	
No	UV test	NA		DV				
No	Cold Cycle On/Off Test	2500 cycles		DV			CTC	
No	Low Temperature Over Life (LTOL)	1000hrs		DV			CTC	
yes	spray salt test	144hrs	3	DV		Bill	BV	
no	ALT	1000hrs		DV			BV	

Mechanical Tests

Required	Test Description	Duration	Qty		Pass/Fail	Responsible	Location	
yes	Dimensional test	NA	30pcs	DV		Bill	BV	
yes	Mechanical Vibration-shiping test	NA	1 box	PV		Bill	BV	ISTA
yes	Drop Test-shipping test	NA	1 box	PV		Bill	BV	ISTA 1A
yes	load test -static weight	200hrs	3	DV		Bill	CTC	10Kg on each string

Optic test

Required	Test Description	Duration	Qty		Pass/Fail	Responsible	Location	Test cond
yes	Face Uniformity	NA	30	DV		Helen/Mark	BV/CTC/Nelar	PTS
yes	Sphere test	NA	30	DV		Helen	BV,CTC/Greenvill	DFSS scor
yes	Gonio test	NA	15	DV		Helen	BV/Greenville	PTS

Why LED "Systems" Matter

- LED performance depends on the *entire system*, not just the chip
- **Critical design factors**
  - Thermal management (junction temperature is key)
  - Electrical design (drivers, current control)
  - Optical efficiency and mechanical stability
- **Reliability approach**
  - Design for Reliability (DFR) across product & process
  - Verification & validation through accelerated life testing
  - LEDs typically rated by lumen maintenance (L70), not burnout

Some Best Practices

Treat listing + install instructions as the "rulebook" (and stage them for inspection)

- Keep installation instructions onsite. These cover essentials like LED mounting, wiring, and power-supply loading.

Get the primary electrical right: circuit, terminations, and a serviceable disconnect

- Line-voltage work must be done by a licensed electrician.

For LED modules, the "big three" are layout + fastening + clean terminations

- Do a quick test light-up before final adhesion so you can confirm even illumination.
  - DO NOT use a battery for this test as this could damage the modules.
- Don't rely on tape alone - add mechanical fastening or silicone edge-seal for module security.
- Terminate the end of each run cleanly .
- Keep runs within the manufacturer's loading/capacity guidance.

Win the outdoors battle: water management + enclosure ratings + heat

- Choose enclosures/components with appropriate ratings for outdoor exposure (wet vs damp).
- Provide drainage/weep holes and keep drainage paths clear.
- Ensure electrical connections are protected from moisture.
- Manage heat: follow spacing requirements for power supplies.