A Modern View of Airport Ground Lighting Systems

A Technology Assessment for General Aviation Airports

Presented By

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Today's Agenda

- Welcome Introduction
  - The General Aviation Subcommittee, What We Do, What is a GA Airport
- Quiz & Prize
- Overall Comparison GA
  - Maybe Boring Data
- Maintenance Good & Bad
  - Factors & Problems
- Review FAA photometric requirements
- Compare Power Topology
  - Review More Interesting Data
- Compare Other Hardware
- Summary
- Thank You
  - Questions

Today we hope to answer some of these questions.

What is the General Aviation Sub-Committee?

What are General Aviation Airports?

What problems do they have?

Are there other technologies that can help?

The General Aviation Subcommittee

Mission & History

- Mission: To enhance the nation's General Aviation airports in the area of safety and utilization through the use of low cost, high performance visual aids for the flying public.
- The committee has been in existence now for over 30 years.

Members

Allen Taylor
Allister Wilmott
Bill Schai
Don Gallagher
Joe Levraea
Mac McIver
Mel Haywood
Richard Mula

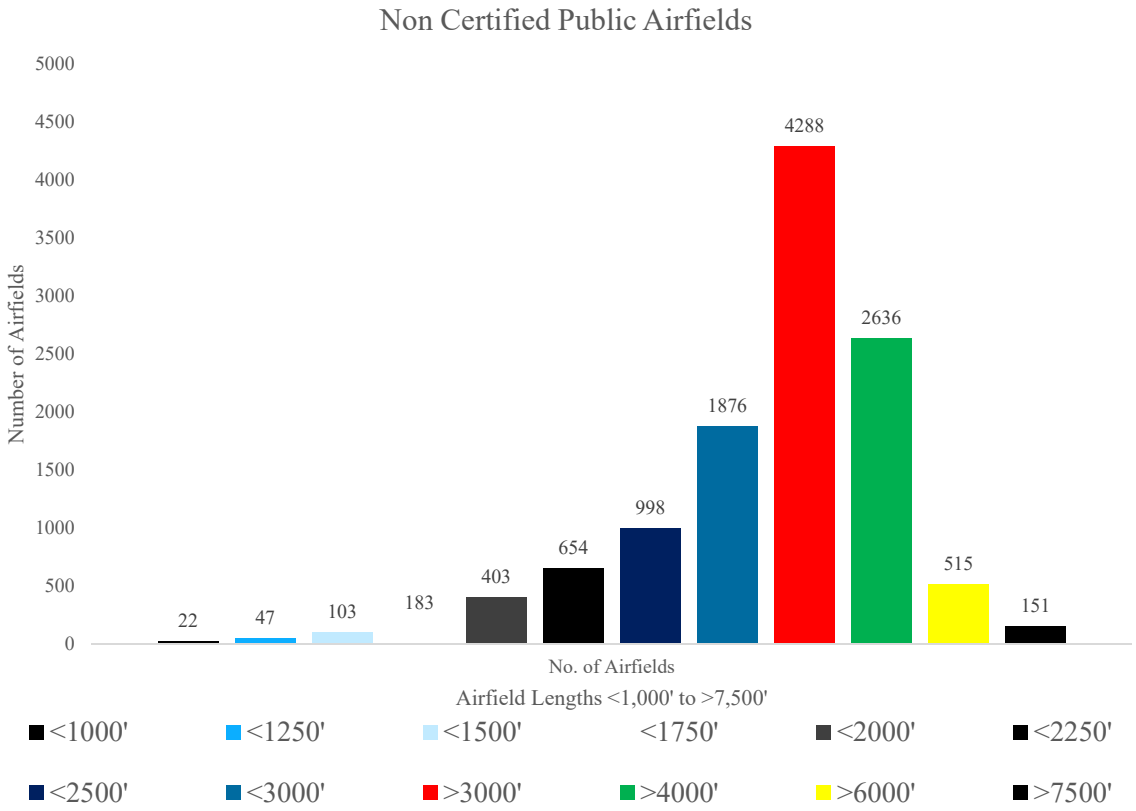
What do we do?

Support efforts to enhance technological advancements for the General Aviation community and to improve safety for the flying public by:

- Holding a minimum of two meetings annually, discussing and implementing updates for the Community Service Airports Visual Aids Handbook,
- Participate in at least one goodwill field trip annually, to engage with small GA airport users, pilots, and operations personnel, to align with current issues and concerns from the flying public,
- Liaise with FAA to help foster awareness and interest in general aviation community needs,
- Seek and enlist aid of Subject Matter Experts for the purpose of completing our mission,
- Maintain and update our publication of the Community Service Airports Visual Aids Handbook,
- Which is available for download online for anyone interested at
  - IESALC :: Illuminating Engineering Society Aviation Lighting Committee » General Aviation Subcommittee

What is a General Aviation Airport?

- Any civil aviation airport that operates other than scheduled air service, usually operating private airplanes and up to corporate business jets.
- Typically operating under VFR conditions with either LIRL or MIRL lighting.



Ground Level Airport Comparison

General Aviation

- Visual aids are key to the GA mission and in some ways more important than at larger hubs that have ATC, ILS, and other electronic nav-aids.
- Lighting can include:
  - ❖ PAPI,
  - ❖ L-860 & L-861 edge lights
  - ❖ Threshold lights
  - ❖ And sometimes REILs all play an important role
- All but few have any more than Runway Edge Lights
- But there always exceptions…

Data

Lansing Municipal Airport, Stat/year

- Flight Operations
  - Air Taxi Operations 5,500
  - Local GA operations 29,700
  - Itinerant Operations 24,200
- 2 RWY's
  - 4022 x 75 feet Medium Intensity
  - 3395 x 75 feet Medium Intensity

Boston Logan Airport, Stat/month

- Flight Operations:
  - 35,858 For June 2016
  - 3,406,989 Passengers for June 2016
  - Cargo 54,309,362 Freight Volume
- Six RWY's
  - 10083 x 150 ft.. High Intensity
  - 10006 x 150 ft. High Intensity
  - 7864 x 150 ft. High Intensity
  - 7001 x 150 ft. High Intensity
  - 5000 x 100 ft. High Intensity
  - 2557 x 100 ft. Medium Intensity

General Aviation Airports

- Type of lighting used
  - Number of lights,
  - Power needed to energize the lights,
  - Cost to procure and operate the lights,
  - Electrical costs become unsustainable.

- Safety
  - What happens if maintenance is neglected, or lacking trained resources
  - Are operations safety compromised by any of the above?

- Maintenance Issues, what about maintenance….?

Maintenance

The Good….

Photo Credit:

Thanks to Mr. Gene Gottlieb


↑ RAMP G


LANSING MUNICIPAL AIRPORT
RWY 09/27
RWY 18/36
TWY B_G
TWY A
SPARE
BEACON 09 WCNE
PAPI 10
ALARMS
AUTO
CANCEL
SEND

Maintenance

The Bad….

Photo Credit:

Mr. Richard Mula

Examples of fixtures found at some locations

This L-860 fixture was found at an unattended small municipal airport. What is wrong with this fixture?

- Alignment of the Fresnel lens
- Junction box was a utility water meter case

Examples of fixtures found at some locations

A second fixture was found nearby, disassembled to a degree but plainly obvious the person servicing it ran out to get spare parts and forgot to come back to finish the job.

It was hard to tell if that happened in the last five or ten years

Examples of fixtures found at some locations

At another airport we found these MIRL, most of the runway edge lights we OK but a few of the fixtures had lenses discolored milky white, until we found one without a lens.

That one and the others had standard 40 watt household bulbs installed

Examples of Fixtures found at some locations

From a distance we were initially impressed that they actually installed some taxiway lights at the exit of the runway on the Taxiway going over to the apron.

Approaching the area we discovered the light fixtures mounted on EMT cemented into cement pads about 32” above the grade.

Note the absence of any frangible coupling

Maintenance

And The Ugly….

Photo Credit:

Thanks to Mr. Bill Schai

Examples of Fixtures found at some locations

We're not sure what this was supposed to be. It could have been an attempt to identify a Heliport TLOF perimeter light off a taxiway at a small municipal airport, with the green fluorescent lamp installed near an asphalt apron that had seen better days.

What is the significance of these photos and common to any type airport?

- These last pictures represent a small percentage of the total, and usually associated with small municipalities, many that don't have regular site personnel and rely solely on the city electrician or landscaper to mow lawns maintain facilities.
  - Consideration of operational requirements, what technical personnel will be available and what level of training would be required to extend the life of the products installed that fall within the budgetary resources the municipality or airport owner can manage in the years to come.
  - An ongoing preventative maintenance program would eliminate these deficiencies.
  - The initial design effort and proper installation of the AGL by qualified contractors should provide the airport facility with a quality product that is easy to install, maintain and cost effective.

Airport Ground Lighting

FAA Requirements Review, Power supplies, and

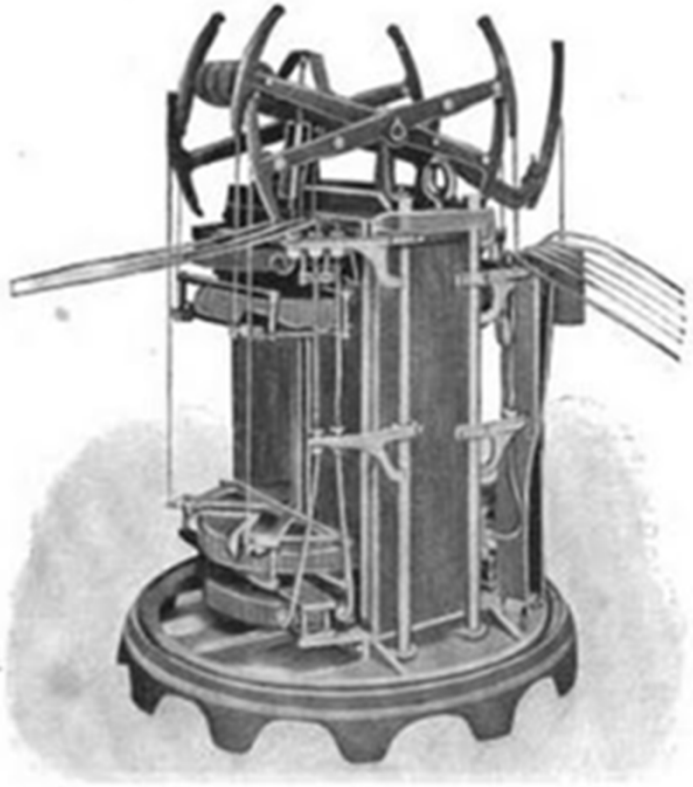
Typical Lighting Photometric Requirements:

From FAA: AC/150-5345-46E & EB 87 REQUIREMENTS

Type	Application	Color	Vertical Intensity (candelas) (a)				
			2° to 10°				10° to 15°
			Minimum Required	Range of Values			Minimum Required
				Minimum	Average	Maximum	
			cd	cd	cd	cd	cd
L-860	VFR Runway Edge	White	15	25	50	75	10
L-860E	VFR Threshold	Green	10	15	30	45	5
	VFR Threshold	Red	3	5	10	15	1
L-860 HR	Heliport Perimeter	Green	10	15	30	45	5
L-860 HS	Heliport Perimeter	Green	10	15	30	45	5
L-861	IFR Runway Edge	White	75	125	250	375	40
	IFR Displaced Threshold	Yellow	37	67	134	201	20
	IFR Threshold	Green	28	46	92	138	14
	IFR Threshold	Red (c)	3	5	10	15	1

Historical Perspective on the CCR

- Early CCR consisted of a mechanical pulley & counter weight assembly that acted with gravity to compensate output thus named Moving Coil Constant Current Regulating transformers.
- The coils were designed to float on a magnetic cushion, whereas the magnetic flux caused the coils to move, thus regulating the output current.
- Input voltages were in the range of 2400 to 12,000 with 6.6 A or 20A outputs. Load regulation was limited to 50% - 100% of rated output.



Traditional Constant Current Regulators

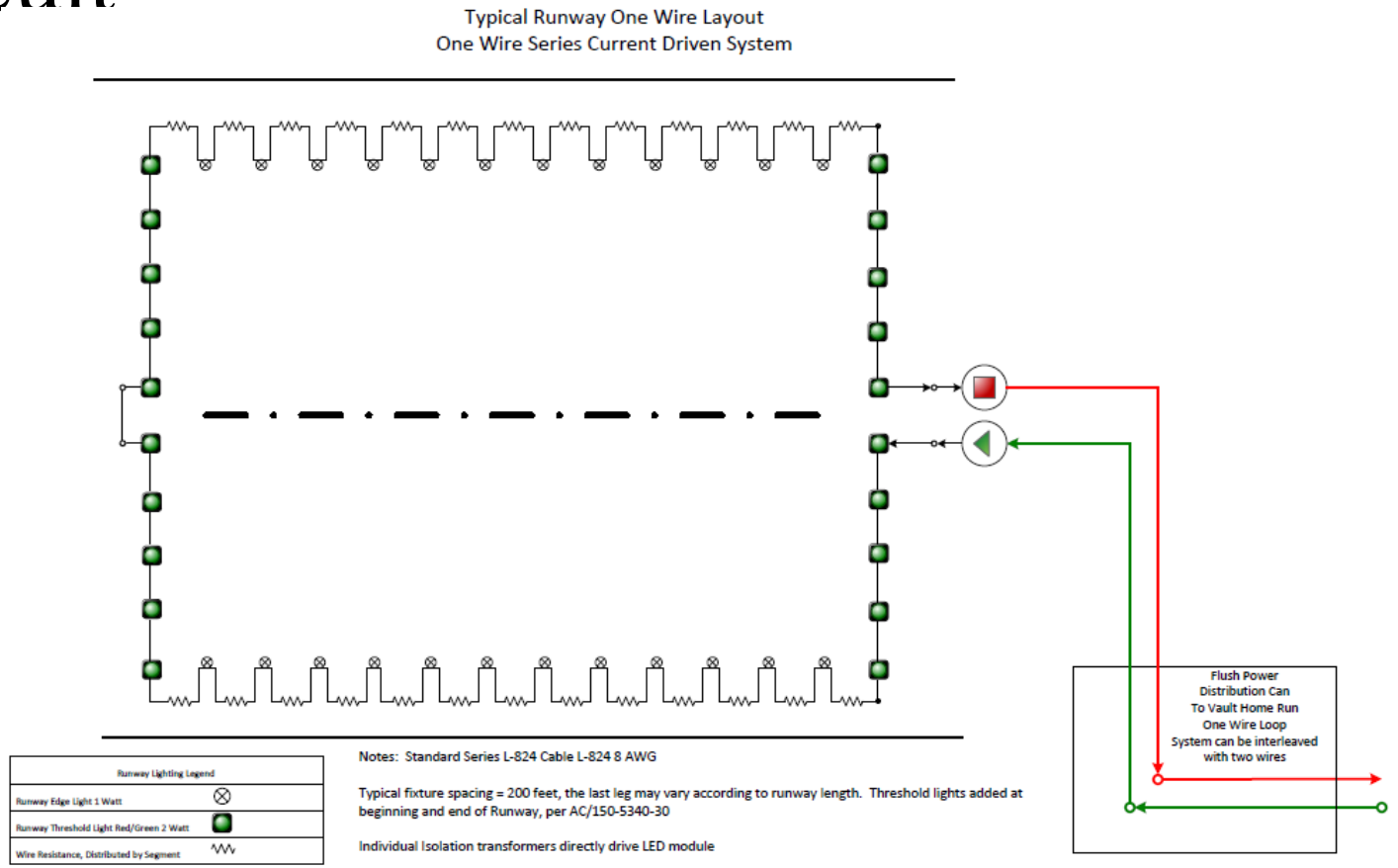
GA Vault & CCR with five 6.6A circuits

Radio Interface L-854

Hub Vault & CCR for 136+ 6.6A circuits

ATC L-890 ALCMS Ctrl Interface

Traditional Constant Current Regulator Circuit



Historical Perspective on the CCR, cont.

- Over the years the CCR has been refined to provide stable regulation infinitely better than the moving coil designs,
- However the CCR is designed not to turn off due to shorts to ground,
- The potential voltage can be on the order of 30 kW/6.6A = 4,545 V_{rms} which can be lethal.
  - 10 KΩ to Gnd. ~ 0.454Amp
- CCR also required TLC maintenance and periodic calibration….
- So is this the best choice for a General Aviation airport ?

Concentrating on the General Aviation Airport:

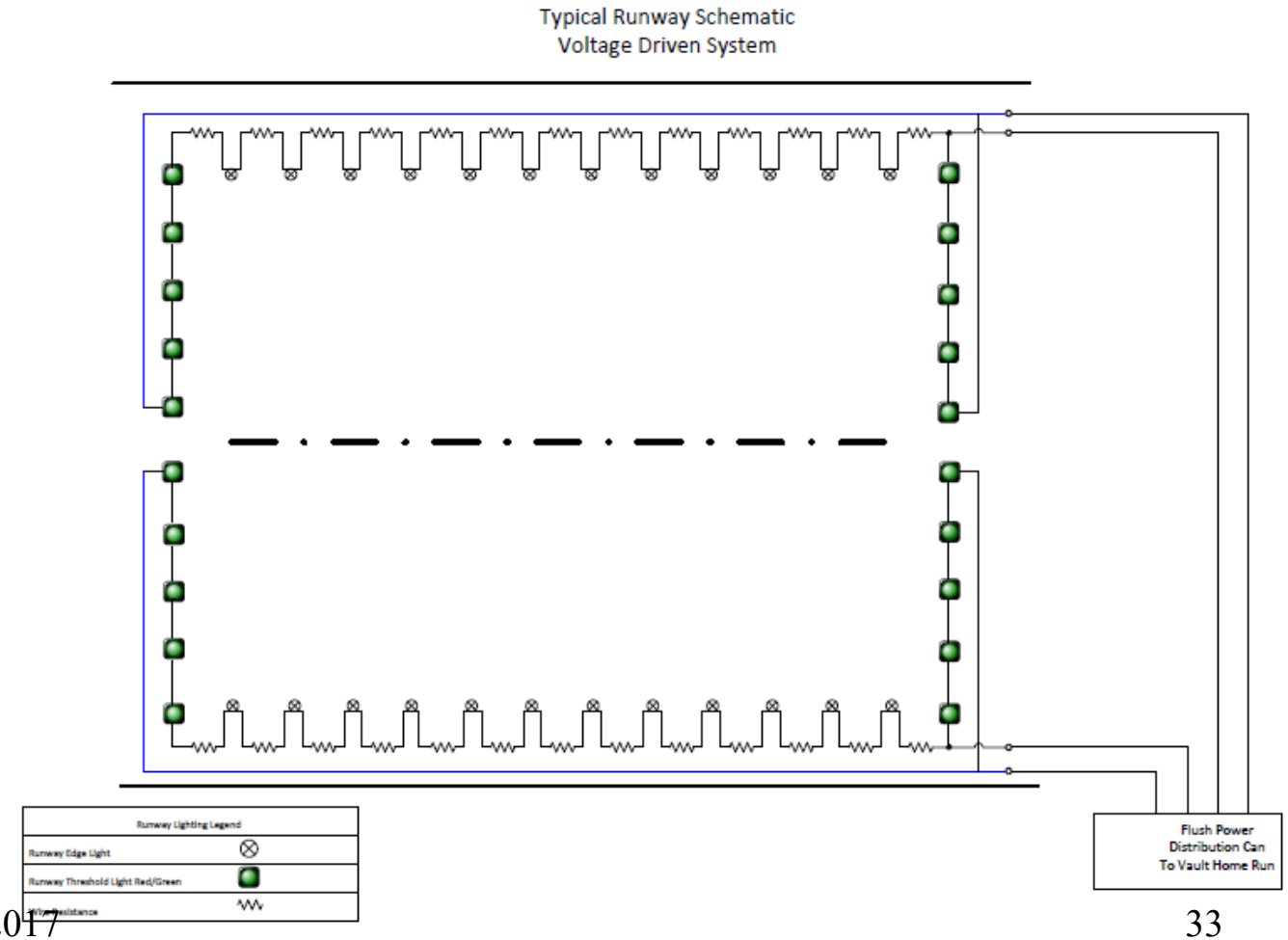
- For Larger General Aviation Airports
  - Using L-861 Medium Intensity Lighting
  - May utilize Constant Current Regulators of standard Thyrister, FerroResonant, or Saturable Reactor type Regulators
  - Often remotely controlled by Pilot Controlled ARCL L-854 Radio Interface
  - Or if Voltage Driven tapped transformer for three steps 100%, 30% & 10% intensity.
- For Smaller Municipal Airports
  - Using L-860 Low Intensity Lighting
  - Typically Low Maintenance programs and Low cost Voltage Systems
  - Maybe interfaced with photocell for night operations, or Pilot Controlled ARCL L-854, single step operation

What are the Minimum Photometrics for GA Runway Edge Lights, 3x rule applies to maximum

For L-860 White Light applications, 100% intensity is set at 25 candela
For L-861 White Light applications, 100% intensity is set at 125 candela
Additionally: L-861 must dim according to EB 67 and according to AC 150/5340-30 for voltage system must be tested at 120 V, 85 V and 60 V, that correspond to the brightness steps B100, B30, & B10.

White Intensity Curves, Reference to Series Current Intensity & Fixture Application							
Step	CCR CURRENT RMS	Minimum Percentage % Candela	Ideal Intensity %	Maximum Percentage % Candela	Voltage Equivalent	L-860 White Candela	L-861 White Candela
B1	2.8 A rms	0.2%	0.4%	0.7%		0.1 cd	0.5 cd
B2	3.4 A rms	1.0%	1.6%	2.1%		0.4 cd	1.9 cd
B3	4.1 A rms	3.9%	5.6%	7.4%		1.4 cd	7.1 cd
B10	4.8 A rms	10.4%	14.8%	19.2%	60 v rms	3.7 cd	18.5 cd
B4	5.2 A rms	16.9%	24.1%	31.3%		6.0 cd	30.1 cd
B30	5.5 A rms	23.9%	34.0%	44.1%	85 v rms	8.5 cd	42.5 cd
B5/B100	6.6 A rms	100.0%	100.0%	100.0%	120 v rms	25.0 cd	125.0 cd

General Aviation Voltage Circuit



Losses in Current & Voltage Circuits

RWY LENGTH	LIGHTING LOAD					SERIES CIRCUIT WIRE LOSSES				ISO XFRMR LOSSES		TOTAL LOSSES		TOTAL LOAD	
2400	FAA	LAMP	POWER	QTY	WATTAGE	WIRE	WIRE RESISTANCE	@ SERIES CURRENT VALUES							
SOURCE	TYPE	TECHNOLOGY	WATTS		TOTAL	AWG	ohm/kft	2.2 A	6.6 A	2.2 A	6.6 A	2.2 A	6.6 A	2.2 A	6.6 A
SERIES CURRENT	L-860 or L-861	INCANDESCENT	30.0 W	24	720 W	8 AWG	0.7780	9 W	81 W	2 W/ea	9 W/ea	57 W	297 W	1137 W	1377 W
	L-861E	INCANDESCENT	30.0 W	12	360 W										
	L-860	LED	1.5 W	24	36 W	8 AWG	0.7780	9 W	81 W	0.2 W/ea	1 W/ea	14 W	105 W	103 W	267 W
	L-861	LED	6.3 W	24	151 W	8 AWG	0.7780	9 W	81 W	0.2 W/ea	1 W/ea	14 W	105 W	219 W	382 W
	L-861E	LED	3.7 W	12	44 W										
Power Formula	$Watts = I^2 * \Omega$ $Watts = I * U$ $Volts = I * \Omega$					VOLTAGE CIRCUITS						NOTE: A GOOD PORTION OF THE SERIES CIRCUIT LOSSES ARE JUST THE CURRENT PASSING THROUGH THE WIRE. THE VOLTAGE CIRCUIT IS SPLIT SO LEFT AND RIGHT SIDES OF RUNWAY DEVELOP 1/2 THE TOTAL SERIES LOSSES			
						WIRE	WIRE RESISTANCE	2-WIRE OHMS	SOURCE AMPS	CABLE LOSSES	TOTAL POWER				
						AWG	ohm/kft	Resistance	Source Amps	Watts	Watts				
VOLTAGE ($120V_{RMS}$)	L-860	LED	2.0 W	24	48 W	10 AWG	0.9989	4.79472	1.00 A	5 W	66 W				
	L-861	LED	6.3 W	24	151 W	10 AWG	0.9989	4.79472	1.63 A	13 W	212 W				
	L-861E	LED	3.7 W	12	44 W										

Note: for low wattage 10/15 W LED series current isolation transformers, the minimum PF must be 0.95, and efficiency must be better than 70%. These factors accounted for in the calculations.

Actual Voltage Drop Measurements

on a 1200 foot array of lights spaced at 100ft. intervals.

First initial tests done with 6.3 Watt LED lights, the load was too small to get any appreciable voltage drops.

Exchanged some lamps with 100 watt incandescent to increase the load.

Measurements made at each lamp fixture.

Distance	WATT	AMP	VOLT
Head- Zero	266.0 W	2.21 A rms	120.7 V rms
100 Ft.	271.0 W	2.26 A rms	120.5 V rms
200 Ft.	265.0 W	2.20 A rms	120.6 V rms
300 Ft.	257.0 W	2.14 A rms	120.7 V rms
400 Ft.	246.0 W	2.04 A rms	121.0 V rms
500 Ft.	244.0 W	2.03 A rms	120.8 V rms
600 Ft.	238.0 W	1.97 A rms	121.0 V rms
700 Ft.	129.0 W	1.08 A rms	120.9 V rms
800 Ft.	125.0 W	1.01 A rms	120.8 V rms
900 Ft.	118.0 W	0.98 A rms	121.1 V rms
1000 Ft.	110.0 W	0.91 A rms	121.0 V rms
1100 Ft.	103.0 W	0.86 A rms	121.2 V rms
1200 Ft.	97.0 W	0.80 A rms	121.1 V rms

Voltage vs Current Systems

Each has its place. The application should drive the design such that the airport experiences the best system at lowest cost of ownership.

- Voltage systems with LED fixtures designed for such a system can offer:
  - All the photometrics required
  - In a simple easy to install turn key kit
  - That will exhibit low maintenance long life approach
  - That is easy to maintain without the need for highly trained technicians to be on hand.
- Current systems, driven by necessity of larger airports, offers:
  - Many vendor choices
  - Designs proven to be reliable
  - But require a higher degree of skill, training, and safety precautions to maintain
  - That only larger airports may have infrastructure and budget for such systems.

Other Specialized GA Hardware

- While most hardware designed to FAA specification is required at airfields around the nation, there are some components that have variations adopted and available to the GA market.
- These include the following hardware of base cans, stake mounts, and cabling.
- Traffic around a GA airport does not require the same heavy duty designs seen at larger airports.
- Examples of base cans and stack mounts design specifically for the General Aviation market are shown below.

Other AGL Hardware, Base Cans

- GA Base Can

- Stake Mounts

- Standard Base Can

Installed Cabling and Maintenance

- Historically wiring in the GA voltage circuits has been left to the installer. They often use what is available, wire nuts for example, as seen in a previous earlier slide.
- Pre-fabricated cables with standard L-823 style FAA approved connectors could be used, to provide waterproof and dependable connections that are easy to install and maintain.
- Plug ‘n’ Play features of cabling removes risk of crossed wires, loose connections, short to ground and improves the safety and reliability of the overall system.

Summary

- Increased efficiency has opened the door to lower-power solutions that make simple voltage systems easy to install and maintain, safer than high voltage CCR circuits and lower cost.
- Manufacturers of LED technology are developing higher efficiency and more powerful devices, with major new product releases at least annually. However availability of specific visible color chromaticity outputs restricts pool of availability to narrow and expensive binning requirements of those LEDs.
- There are no reasons that low-cost fixtures can't be certified for FAA applications that previously required much higher power levels as found in traditional CCR-driven circuits.
- The GA airport manager is challenged to find local resources that have experience and training to work on series current systems.
- Low-voltage systems offer the advantage that any qualified electrician can easily understand the system, which is about as simple as any commercial lighting.

Special Thanks to:

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And John Bogart , Bill Schai and Steve Schneider for their support and help

- Thank you for your attention.
  - Questions?

Handbook available at:
IESALC :: Illuminating Engineering Society Aviation Lighting Committee » General Aviation Subcommittee

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