LED Specification White Paper

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Strategy: Provide assistance to specification writers that are tasked with identifying the most cost-effective energy efficient lighting for their properties in sectors such as commercial, industrial, institutional, military or others, beyond single family residential properties.
Tactics: Identify key specification areas of focus and language to maximize savings at the lowest cost of ownership with the most reliable LED lighting technology.

Industry Leadership: Charlie Szoradi is the Chairman and CEO of Independence LED. With award winning technology, patents filed in over 40 different countries, and installations across the public and private sector in both the US and overseas, Independence LED focuses on reducing short and long term operating costs for property owners and operators. Independence LED has direct experience as a US Manufacturer and has provided industry leadership to date over multiple years:

2013: The Independence LED tubes won the 2013 Best Lighting Retrofit by the U.S. Green Building Council's Urban Green Award.
2012: The Company provided the Report to Congress on LED Import Tariffs at the request of the U.S. International Trade Commission.
2011: The Company won the Green Business of the Year Award by the Main Line Chamber of Commerce.
2010: The Company brought its manufacturing from China to southeastern Pennsylvania, USA.

Independence LED tubes have been installed on over 20 ships for the US NAVY's Military Sealift Command since 2011. The company focuses on linear LED "tube" lighting and linear fixture applications vs. many manufacturers that provide other lighting solutions and fixture types. The company has developed over six incremental improved versions of its LED tube technology since 2010, and leads the industry with the advanced thermal management and the strongest warranty in class.

This LED Specification White Paper includes several key topics:

- Fixture Description over Tube Count
- Fixture Efficiency over Tube Efficiency
- External over Internal Driver Advantages
- Light Output and Beam Angle Adjustment
- Sample Submissions
- Total Cost of Ownership
- Smart Controls
- Battery Backup
- Made in USA
- Class A-10 International Standards
- Appendix: Danger of Internal Drivers

Fixture Description over Tube Count:
Focus on FIXTURE EFFICACY over individual tube performance and cost. This is a key way for property owners or operators to review energy solutions over commodity units. As an example, instead of listing 6,000 4' tubes and 11,000 2' tubes in a solicitation bid scope, a buyer could list the existing fixture conditions to give visibility to the suppliers that can then develop relevant solutions. The advantages of this fixture solution approach are illustrated in the "Total Cost of Ownership" section of this report.

Sample Specification Language:
Fixture Type 1: Fluorescent Fixtures with (2) 4' T12s at 40 watts each, totaling 80 watts per fixture
Volume: 3,000 fixtures
Fixture Type 2: Fluorescent Fixtures with (2) 2' T12s at 20 watts each, totaling 40 watts per fixture
Volume: 5,500 fixtures

Fixture Efficiency over Tube Efficiency:
If property owners or operators specify a cap on wattage per tube (e.g. 18 watts) they reduce the opportunity for any given supplier to de-lamp fixtures with high output LED tubes. In lieu of a fixture wattage cap, use specification language such as a requirement to reduce the existing fixture wattage by a certain amount. This encourages suppliers to provide solutions that deliver maximum savings.

Sample Specification Language:
Qualifying LED tube solutions must reduce fixture wattage by a minimum of 40% per fixture.

External over Internal Driver Advantages:
External Drivers have multiple efficiency, smart control, operation, and life safety advantages over Internal Drivers.

Efficiency: By separating the heat created by the drivers from the LEDs on the linear "Tube" modules, the combined system runs more efficiency, maintains its color more consistently, and lasts longer. Heat is simply the enemy of the LED. (See the sample Dangers of Internal Drivers in the Appendix).

Smart Control: External Drivers provide increased flexibility over internal drivers when it comes to maximizing future connectivity for dimming, occupancy sensors, light harvesting, alert signals, and Wifi control. Many end users are focused in the short term on the energy savings with LEDs but the modular advantage of an external system is the ability to improve the technology as it evolves by connecting into other smart controls.

Operation: Since the External Driver is a separate module it can be easily replaced in the same way that fluorescent ballast is replaced upon failure without throwing out the whole tube. This is the simple model of "don't throw the baby out with the bathwater", since the LEDs and the tube component are more valuable than the driver component. Modularity creates operating as well as energy efficiency. Think of the driver as the starter on a car or the power supply on a computer. Specify Non-Proprietary Drivers for maximum flexibility over time to purchase if necessary additional drivers. For failure diagnostics, if a tube goes dark completely then the failure is most likely in the driver vs any of the diodes on the tube, but personnel can always easily cross check by simply connect a failed tube to a nearby fixture. Given that the drivers are the weak link *Achilles' Heel* of the LED system, request a nominal extra inventory of drivers (e.g. 1 per 100 Tube sets) to have at hand in the event of failure. This is not unlike stocking extra ballasts.

Life-Safety: Fluorescent tube fixtures to date have been typically designed to bring Alternating Current (AC) line voltage typically at 120V to 240V into the fixture and then step it down to safer lower voltage via the fluorescent

ballast to Direct Current (DC). The danger of using internal driver LED tubes is that the step down to the lower voltage occurs inside the tube. So the installer of internal drivers bypass the ballast and run the higher voltage directly into the socket "tombstones" of the fixture. This means that the dangerous line voltage is right at hand in the fixture. If personnel touch the sockets, they WILL RECEIVE A SHOCK, and they are at risk of falling back off a ladder at the 120V level breaking an arm, hitting their heads, or worse. There is an increased likelihood of fatality for fixtures that are powered with higher 240V with the internal drivers. By contrast, external driver LED technology mirrors the model of the original fixture design by replacing the fluorescent ballast with the external driver and stepping down the voltage as it is fed into the tubes for increased safety.

Sample Specification Language:
Qualifying LED tube solutions must include options for external drivers that are non-proprietary to a sole source, so that MSC can replace the drivers if necessary either during or after warranty periods. Combined Driver and Tube systems must meet Underwriters Laboratories (UL) Classification for retrofits including those fixtures designated in this solicitation. At least 1 additional extra stock external driver must be provided for every set of 100 tubes. A tube set is defined as the system of driver to tubes, so if a driver powers a pair of tubes in a particular fixture type then only 1 extra driver would be required for 200 tubes, given that there are 100 tube sets.

Light Output and Beam Angle Adjustment:
The amount of light directly under the fixture is a key aspect of performance but not the only criteria for a successful retrofit. The dissipation of light across any given surface is the key counterpoint to foot candles or LUX directly under the fixture. Since LEDs are more directional than the incumbent omni-directional fluorescent tubes, specify beam angle adjustment for maximum flexibility.

Sample Specification Language:
Qualifying LED tube solutions must include a means for beam angle adjustment either through rotatable cuffs or other UL approved systems.

Sample Submissions:
End users typically have the goal for the new LED tube retrofit technology to not only provide energy savings, but also to meet or exceed the fixture light output and beam angle distribution below and to the sides of the fixtures. Third party testing in laboratories is one path to identify the spread of light, but there is no substitute for seeing the output first hand. Review samples for qualifying bids in a second round "short list" of finalists. This path may also identify certain suppliers for awards on specific fixtures vs total contract awards. The added complexity is offset by the fact that the LED products last for 7 years at 24/7 operation and about 20 years in a single shift office environment. Once field testing has been conducted for certain suppliers and fixture solutions, the end user will have a roster of fixture choices and the burden of review will reduce accordingly. This approach enables the end user to assess the time required to retrofit the designated fixture. Plus, readily available foot candle and LUX meters give end users the ability to quickly see the output of light directly under each sample retrofit as well as the readings at one or more distances adjacent to the center point of the fixtures.

Sample Specification Language:
Qualifying LED tube solutions that are identified as finalists may be required to submit at least one set of tubes and drivers for one or more set of fixtures. The intent of this aspect of the solicitation is to provide in-field verification of light output prior to contract approval. This solicitation reserves the right to award portions of the contract to different suppliers.

Total Cost of Ownership:
Use a 7 Year Cost of Ownership metric to select the lowest cost solution provider. With an average of 50,000 to 60,000 hour life, a typical 24/7 illumination (8,760 hours per year) yields 7 years of life.
Here are the straight forward formulas:

- LED Fixture Watts / 1,000 X Annual Hours of Operation = Annual kWh Consumption
- Annual kWh Consumption X Cost / kWh = Annual Electricity Cost
- Cost of LED Tube and Driver Retrofit Kit + (Annual Electricity Cost x 7 Years) = 7 Year Cost of Ownership

If the warranty period does not cover 7 years, then the supplier needs to include the additional cost of the product at the year end of the warranty period. Please note that the straightforward solution of Cost of Ownership encourages solutions that benefit the end user. Previous solicitations that had a cap on the wattage per tube did not have a means to include high output LED tubes for del-lamping or reward solutions that were lower in wattage than others. Think of the total cost of ownership as the Cost to Commute to Work over Time. A more expensive hybrid car that is fuel efficient will deliver a lower cost to commute. With this formula approach, property owners or operators will have the ability to review the different submissions and select the lowest cost solution of the qualifying suppliers.

Sample Existing Condition: Fixture with two (2) 40 Watt T12 fluorescent tubes with a total of 80W per fixture.

Example Submission 'A': Watts per LED Fixture: 30W
(2) 15 Watt LED Tubes (Imported) - Unit Cost per Tube: $35 and Cost per Fixture Retrofit: $70

Example Submission 'B': Watts per LED Fixture: 24W
(2) 12 Watt LED Tubes with optimized lumens/watt - Unit Cost per Tube: $40 and Cost per Fixture Retrofit: $80
(Note: 112 lumen/watt yields 2,688 directional lumens / fixture while 90 lumens per watt at 30 watts from Example 'A' may yield a comparable 2,700 lumens / fixture with a higher cost to operate each year.)

Example Submission 'C': Watts per LED Fixture: 22W
(1) 22 Watt LED Tube - Unit Cost per Tube: $70 and Cost per Fixture Retrofit: $70

Annual Run Time (h)	8,760
Cost / kWh	$0.12

Fixture Solutions	Tube + Driver Cost	Fixture Kit Cost	Tube Watts	Fixture Watts	Annual kWh	Annual Elect. Cost	7 Year Cost (Equipment + Annual Elec.)
Existing: (2) 40 Watt T12s + Ballast	$2	$19	40	80	700.8	$84.10	$607.67
(2) 15 Watt LED Tubes (Imported)	$35	$70	15	30	262.8	$31.54	$290.75
(2) 12 Watt LED Tubes with Optimized lumens/watt	$55	$110	12	24	210.24	$25.23	$286.60
(1) 22 Watt LED Tube:	$70	$70	22	22	192.72	$23.13	$231.88

Both Solutions 'B' and 'C' beat 'A' in lowest Total Cost of Ownership, even though A is the lowest cost per tube.

Please Note:
#1: Check the warranties on each product, because if the warranty is 5 years or less, then the total cost may be double the costs reflected above for any of the solutions since the tubes may need to be replaced. Plus, the redundant labor cost is an additional penalty to the energy saving performance for the tubes with less warranty coverage.

#2: The electricity and fuel costs have historically risen by 3% per year over past decades with expected increase to continue over future years, so the savings advantages will be even greater with the optimized solutions. Plus, the higher the cost per kWh and the longer the run time, the more dramatic the savings will become with the lower wattage fixture solutions.

#3: Total Cost of Ownership is key for delamping fixtures such as the common 2' x 4' fluorescent troffers that often have three or four tubes at up to 128 watts (four 32W T8s). A tube for tube retrofit with imported LEDs might result in (4) 15 watt LED tubes at $35 each for a total of 60 watts and $140 retrofit cost per fixture. A more cost-effective solution is a pair (2) 22 watt LED tubes at $69 each for 44 watts and $138, with the Made in America quality assurance and a 10 year vs a 5 year warranty. The cost is equal or less to start, the energy consumption is lower and the warranty is stronger.

Sample Specification Language:
Qualifying LED tube solutions will be reviewed on the Total Cost of Ownership over a 7 Year Term based on these formulas:

- LED Fixture Watts / 1,000 X Annual Hours of Operation = Annual kWh Consumption
- Annual kWh Consumption X Cost / kWh = Annual Electricity Cost
- Cost of LED Tube and Driver Retrofit Kit + (Annual Electricity Cost x 7 Years) = 7 Year Cost of Ownership

If the warranty period does not cover 7 years, then the supplier needs to include the additional cost of the product at the year end of the warranty period. The calculations are based on 24/7 operations with 8,760 hours per year and $____Cost / kWh. ($.12 US Average and $.20 in markets like New York City)

Smart Controls
Dimming is one of the keys to smart controls. The specifications should call for a dimming driver in the event that upon installation or in the future, the owners or operators of the property can connect to the driver with controls to dim the lights. This approach provides a, "smart control enabled" solution. Manual dimming is a natural energy saver, but there are also other advantages through automation:

- Light Harvesting – Save money when lights dim automatically based on photo cells that measure ambient room light levels from windows or skylights.
- Demand Response – Save money when lights dim automatically based on times of day to reduce peak load curves. The level of dimming can be set at 10% or other levels that are barely noticeable by property occupants. As an example, the summer hours from 3 pm to 7 pm are often the times that create the highest burden on utility companies. Utility companies are provide off-peak and on-peak rates and the on-peak rates are often multiple times higher in cost than the off-peak equivalent hours.
- Occupancy Sensors – Save money when lights dim or go entirely off based on occupancy levels in any given area of a property. As an example, this is relevant in facilities such as warehouses where certain aisles are used less frequently than others.
- Emergency Alerts – Save lives. Consider specifying lights that can strobe or pulse on demand when there is an emergency situation. As an example, this is relevant for schools where the headmaster or an administrator can signal the students with flashing lights when there is a dangerous situation such as a break in.

Sample Specification Language:
Qualifying LED tube solutions must include a driver system that has the capacity for dimming.

Battery Backups
Specify products that have the ability to tie into battery backups for key emergency areas of a given property.

Sample Specification Language:
Qualifying LED tube solutions must include a specification of one or more companion battery backup that is compatible with the LED tubes for applications such as emergency stairs or other areas that require back up power for emergency egress.

Made in USA:
Specify products that are Buy American Qualified for the American Recovery and Reinvestment Act (ARRA). The key to the Buy American Qualifications is substantial material transformation. According to ARRA, qualifying products must include, "work that has been processed into a specific form and shape or combined with other materials to create a material that has a different property than the individual raw materials." This is the cornerstone of American job creation given that, according to ARRA, "There is no requirement with regard to the origin of components or subcomponents in manufactured goods used in a project, as long as the manufacturing occurs in the United States." Overall, there are numerous suppliers that claim to have US Made products and in some cases they submit for LM79 Testing in the US to create the perception of US Manufacturing when in fact they are only adding end caps or label stickers vs the complete sub assembly and production in the US. Overall, look for authentic Made in America products.

Sample Specification Language:
Qualifying LED tube solutions must include a letter testifying that, "The LED products submitted for this solicitation meet the Buy America Qualifications according to the American Recovery and Reinvestment Act (ARRA). The LED products include substantial material transformation in the US, including sub-assembly manufacturing and total tube assembly with a combination of domestic and/or imported components."

Class A-10 International Standards:
In addition to the specification outlined above, we recommend reviewing and using most if not all of the information in the Class A-10 International Standards for future solicitations in addition to the information outlined above. (See the following pages)

Class A-10 “Advanced” LED Tube Technology

The International Class-A “Advanced” LED Tube Standards include 10 Criteria that sets the benchmark for highest performance in the LED Tube industry.

#1: Efficiency: 100 lumens / watt or higher.

#2: Longevity: 50,000 hour rated life or higher with third party LM80 testing.

#3: UL Certification: Underwriters Laboratories (UL) Classified, not just recognized LED Driver.

#4: CE Certification: Conformity European.

#5: ISO-9001:2008 Certification: The International Organization for Standardization to foster consistency in LED Tube product delivery and quality assurance.

#6: Thermal Management: Heat Sinks with over 7” (17.78cm) of circumferential “perimeter” conductive surface.

#7: Power Supply: External Driver with multi-tube Driver Options for fixtures.

#8: Warranty: 5 years or longer on both the Tube and Power Supply.

#9: Rebate Ready Products: Performance Criteria across multiple regions and countries.

#10: LED Tube Light Quality and Control: Color Rendering Index (CRI) options for 80 or higher + Dimming down to 20% or lower + Beam angle adjustment within existing tombstone end brackets.

Sample: Independence LED relative to Class A-10 Standards

#1: Efficiency: 100 lumens / watt or higher.
Independence LED: 112 l/w at CRI 70 and 100 l/w at CRI 85

#2: Longevity: 50,000 hour rated life or higher with third party LM80 testing.
Independence LED: 50,000 hour life (L_{70}) with LM80 testing.

#3: UL Certification: Underwriters Laboratories (UL) Classified, not just recognized LED Driver.
Independence LED: UL Classified.

#4: CE Certification: Conformity European.
Independence LED conforms to the following directives:
Artificial Optical Radiation Directive: 2006/25/EC
Low Voltage Directive (LVD): 2006/95/EC
Electromagnetic Compatibility (EMC) Directive: 2004/108/EC
Restriction of Hazardous Substances Directive (RoHS): 2002/95/EC

#5: ISO-9001:2008 Certification: The International Organization for Standardization to foster consistency in LED Tube product delivery and quality assurance.
Independence LED: Certified: ISO-9001:2008

#6: Thermal Management: Heat Sinks with over 7" (17.78cm) of circumferential "perimeter" conductive surface.
Independence LED: 9.13" (23.19cm) of circumferential conductive surface via its deep fin aluminum heat sinks.

#7: Power Supply: External Driver with multi-tube Driver Options for fixtures.
Independence LED: Single, Double, Triple, Quad, and Six Tube External Driver configurations.

#8: Warranty: 5 years or longer on both the Tube and Power Supply.
Independence LED: 10 Year Limited Lifetime Warranty up to 60,000 hours on the LED Tubes and 5 years on the Power Supplies. (Extended 10 Year Warranty on the power supplies are available for certain applications.)

#9: Rebate Ready Products: Performance Criteria across multiple regions and countries.
Independence LED: The company's tubes were some of the very first to qualify and set the rebate standards in 2011 through the industry leading Con Edison Commercial and Industrial Incentive program, administered by Lockheed Martin. An additional U.S. example: The DesignLights Consortium (DLC) Qualified Products List, ranging from Troffer fixtures to Industrial High Bay fixtures, sets minimum lumen output levels per fixture. The Independence LED multi-tube fixtures meet or exceed key levels. For example, the 2'x 4' (4) Tube Troffer fixture emits 4,000 lumens and the 4' (6) Tube High Bay fixture emits 19,000 lumens.

#10: LED Tube Light Quality and Control: Color Rendering Index (CRI) options for 80 or higher + Dimming down to 20% or lower + Beam angle adjustment within existing tombstone end brackets.
Independence LED: Offers all three of these light quality and control features.

Appendix:

Danger of Internal Drivers

Sample ABS Certification

The Danger of Internal Driver LED Tubes

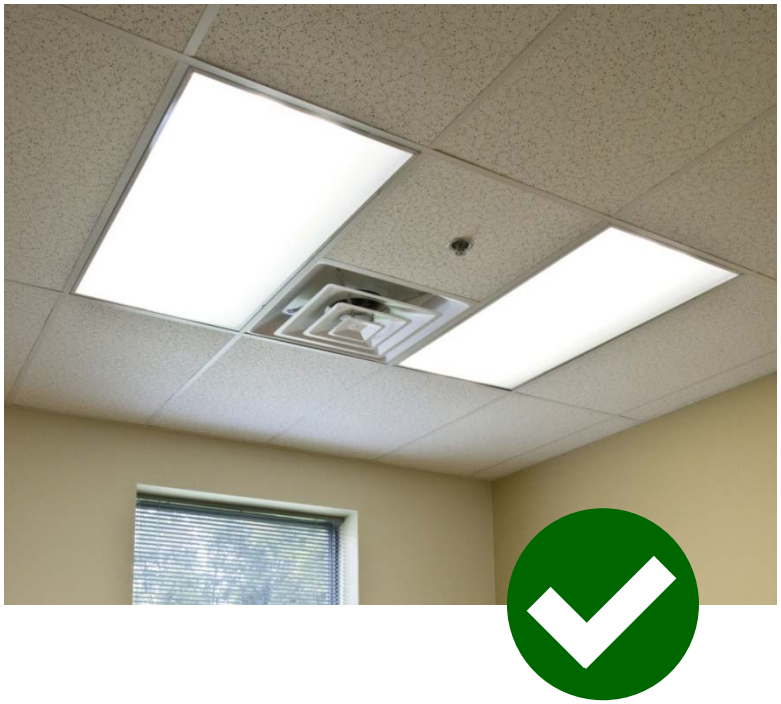
SAMPLE: The Failure of Internal Driver LED Tubes

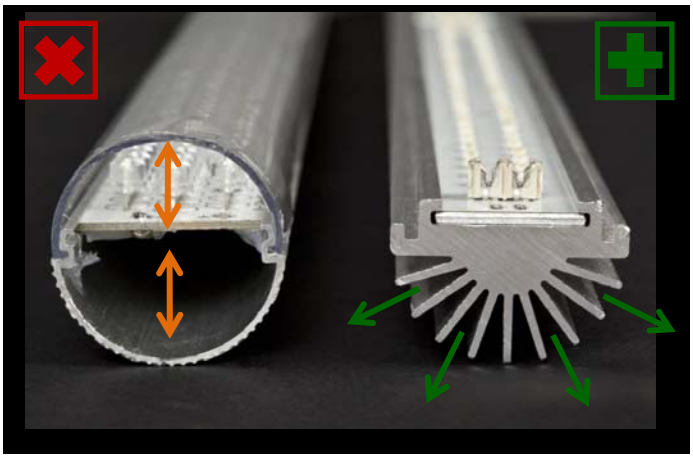
Burn Zone

Burn Zone

INTERNAL Drivers Burn Out LED Tubes.

SAMPLE: The Success of the Independence External Driver Tubes





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EXTERNAL Driver Tubes perform better than internal driver tubes and they also have advanced Thermal Management Heat Sinks that dissipate rather than trap the heat that damages the diodes.