FINAL REPORT TEMPLATE

PROJECT CODE:	2020-1073 – IOT LED Energy Saving (and Safety) – Stage1 Small stock Slaughter
PREPARED BY:	**Plant Engineer**
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1.0 EXECUTIVE SUMMARY

The Meat Processing Pant hoped to take a first step into incorporating IOT technology in its operations by investing in an IOT LED lighting system. The project entailed the lighting selection, design and evaluation of a baseline batten type LED system from Kraftlig LED, which is unique in the technology.

The incorporation of this fundamental smart technology would allow the Plant to further invest in a second stage SMART technology that could collect data from operating environments.

Unfortunately, although the batten assembly showed promise in design and technical suitability, the fundamental solution in terms of physical mounting led to the project being unsuccessful, as it did not suit this particular production facility's needs.

The solution is applicable in less critical environments and certainly still shows value based on operator requirements in individual cases.

2.0 INTRODUCTION

The Meat Processing Plant is continuously looking to take advantage of IOT technology, which is a natural progression of industry practice in an Information Technology era. Kraftlig LED was identified as a provider of technology in the LED lighting environment, and the technology aligned closely with the outcomes that the Plant envisages for its operation.

IOT lighting is not a new idea as such, and has been employed in warehousing applications during the last decade, but what made the Kraftlig LED option stand out was the fact that they had employed the technology in a "batten" style light, which is conceptually new and applicable in industrial and commercial applications.

The Plant went about the selection of this technology in an iterative approach to evaluate the performance of the actual fitting and foundational technology before attempting a secondary phase of Cloud based data gathering and Building Management via Information Systems.

3.0 PROJECT OBJECTIVES

Project objectives were:

3.1 Engineering and lighting design

This objective included product selection and then an associated Lighting design inclusive of Emergency lights for the Small Stock Slaughtering facility.

3.2 Manufacture and supply

This objective included a sample LED light with demonstration of functionality

3.3 Installation, configuration and Training

This objective included installation and commissioning

3.4 Monitoring of performance and energy efficiency

This objective was to evaluate performance based on theoretical assumptions.

4.0 METHODOLOGY

4.1 Engineering and Hardware evaluation

4.1.1 LED performance

The Kraftlig LED batten had a superior rating in terms of LED life (120 000 hrs/ 7 year warranty) compared to other and suppliers manufacturers (50 000 – 100 000hrs /5 year warranty), which was fundamental in supplier engagement. Fundamentally the investment had to have the longest possible life without defects.

4.1.2 Enclosure suitability

The enclosure was evaluated for IP rating, chemical resistance and plastics suitability. Furthermore, the enclosure was validated in terms of “clean” lines and suitability in a meat processing facility.

It was found that the IP rating of IP67 was applicable to the environment, and that the chemical resistance was well within conformance to the environment and cleaning operations. (See Appendix 1 – Chemical Resistance)

4.1.3 Lighting performance

Lighting performance had to be compliant with Quality Control specifications of at least 600 Lux at inspection areas, and then also provide a natural Color Temperature that would allow for best lighting aspect.(See Appendix 3 – Lighting Design) The Specifications required were analysed according to a parameter sheet as shown in Appendix 2 – Data Sheet Parameters.

Lighting quality was selected accordingly as follows:

QTY	Product Code	IP Rating	Impact	CRI	Colour	L70	Warranty	Photo
			IK	ra	K	hrs	yrs	
50	KR40WLL 44.5W LED LOW GLARE HARSH LINEAR 5000K, ~ 7,500 lm	IP67	IK 10	>90ra	5000K	>120,000	7	
6	KR20WLL 20W LED LOW GLARE HARSH LINEAR 5000K, ~ 3,450 lm	IP67	IK 10	>90ra	5000K	>120,000	7	
35	KR40WLL-EM 44.5W LED LOW GLARE HARSH LINEAR 5000K, ~ 7,500 lm	IP67	IK 10	>90ra	5000K	>120,000	7	
4	KR20WLL-EM 20W LED LOW GLARE HARSH LINEAR 5000K, ~ 3,450 lm	IP67	IK 10	>90ra	5000K	>120,000	7	

4.2 Functional Evaluation

4.2.1 Dimmability

One of the main advantages of the system on offer from Kraftlig as a Phase 1 solution was the incorporation of the dimmable function of individual LED battens. This allowed for setting each unit to an output level associated with the tasks being performed in the particular area, as well as then setback of light output when the area was not occupied. This would then ultimately allow for each functional area to be set to a certain lighting level as required at different times of day.

This programming would be easily achieved by preprogrammed remote control.

4.2.2 Microwave programming

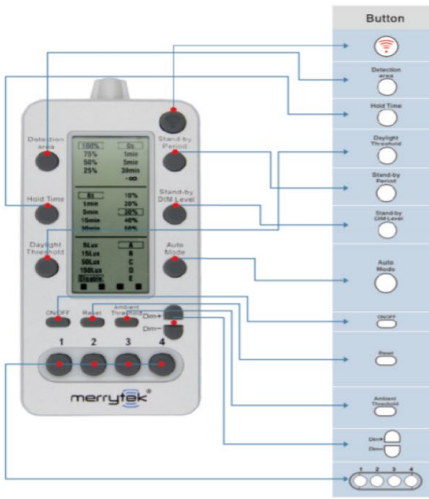
The programming of the microwave sensor showed promise in evaluation, and has the ability to make most of the sensor's ability to respond to situation specific requirements. The functionality as a base line unit showed good promise with the following specifications programmable to each batten unit:

Specifications

- Operating Freq: 5.8GHz +/-75 MHz ISM waveband
- HF Radiated Power: 0.5mW Max.
- Detection Area: 100% / 75% / 50% / 25%
- Hold Time: 8s / 30s / min 3min / 20min / 30min by Remote Control 0s / 10s / 1min / 3min /

5min / 10min / 30min / Disable

- Stand-by Period: 0s / 1min / 3min / 10min / 30min /Disable by Remote Control 0s / 10s / 1min / 3min / 5min / 10min / 30min / Disable
- Daylight Sensor: 5lux / 15lux / 30lux / 50lux / 100lux / 150lux / Disable by Remote Control 5lux / 15lux / 30lux / 50lux / 100lux / 150lux / Disable
- Stand by Dim Level: 10% / 20% / 30% / 40% by Remote Control 10% / 20% / 30% / 40% / 50%
- Constant Light Dimming Area: 10% to 100% (+/- 5% unit for adjustment)
- Mounting Height: 12m Max
- Detection Angle 150^{o} (Wall Mounting), 360^{o} (Ceiling Mounting)



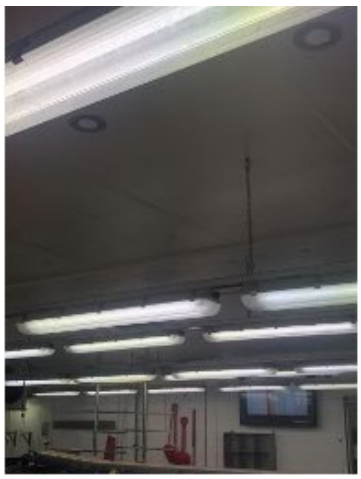
Button	Name	Description
	Transmit	Uploads the settings
	Detection Area	25%/50%/75%/100%
	Hold time	The timeout from 100% to dim 8S/1min/5min/15min/30min
	Daylight Threshold	5Lux/15Lux/50Lux/150Lux/ Disable
	Stand-by period	The timeout from dim to off 0S/1min/5min/30min/+∞
	Stand-by DIM level	10%/20%/30%/40%/50%
	Auto mode	1. Movement Motion detect 3-6m 2. Presence detect 3-6m 3. Presence detect with daylight harvesting 3-6m 4. High mounting: 6-15m 5. High mounting with daylight harvesting : 6-15m
	ON-OFF	Permanent ON/OFF
	Reset	Press "Reset" button for factory testing purpose only. Detection Area: 100% / Hold Time: 1min / Stand-by period: 3min / Stand-by dim level: 20% / Daylight sensor: Disable
	Ambient Threshold	Pressing this button, will disable the daylight harvesting function, which is offset if the current threshold is not suitable
	Dim+ / Dim -	Adjust the target light level according to the ambient light
	1/2/3/4	4 optional quick settings

Features

- 120-347Vac (50/60hz) Input Voltage
- On/Off 3 step dimming function
- Daylight Threshold and daylight harvesting function
- Up to 12m mounting height
- Functions can be set by remote control

4.3 Installation

The following images show a typical setup for the installation of the batten lights. This method had been utilized throughout different areas of the Plant as a standard application.


Upon execution of installation, it was determined by key stakeholders that the installation of batten lights in this manner did not meet with expectations of good practice in a slaughtering environment. This part of the project ultimately led to the decision not to install these lights in production areas, and alternative solutions would have to be employed rather than the intended Kraftlig solution.

Ultimately it was decided to re-invest in clean room lights by Kingspan in order to attain the required level of hygiene and functionality from a operations and cleaning point of view. The images below show the lights that are now due to be installed in the Small Stock processing floor.

The Kraftlig LED lights have however been installed in non-production areas and have proven flexible and operationally sound in these non-critical applications.

5.0 PROJECT OUTCOMES

Ultimately the outcome of this project was not successful. The main purpose of the project was to adopt a foundational smart technology that could be expanded to an IOT system, but because of the requirement set by key stakeholders late into the project, execution of this solution was not feasible.

The fundamentals of the technology still remains sound, and if the technology could be housed in a physical unit applicable to current requirements, it could have a positive impact on the industry, especially in relation to IOT and its adoption in wider industry.

The investment made by the Plant is not completely lost, due to the fact that the units still have application in non-production areas, and ultimately will still serve the purpose of reduction in energy consumption. This may not be as tangible as it would be in normally occupied or high occupancy areas such as production.

6.0 CONCLUSIONS/RECOMMENDATIONS

Key recommendations in this project would be:

- Ensuring that key stakeholders are fully committed to solutions before they are executed, understanding that the resource and investment required should not be expended without proper consideration and investigation
- Suppliers are vested in solutions that are suitable in an industry that is not always familiar
- Further engagement and feedback is supplied to enable outcomes that suit the industry and its particular needs

7.0 APPENDICES

7.1 Appendix 1 – Chemical Resistance

Makrolon Environmental Resistance

Makrolon polycarbonate sheet may be used in a diverse range of environmental conditions. However, as with any thermoplastic, some environmental conditions have proven to be detrimental to Makrolon sheet. Varying degrees of stress, strain and temperature may also alter the resistance of Makrolon sheet; consequently fabricated parts should be tested thoroughly under actual in-service conditions prior to final design.

Makrolon is resistant to:
Chemicals:
Amyl Alcohol Aluminum Chloride Aluminum Sulphate Ammonium Chloride Ammonium Nitrate
Ammonium Sulphate Antimony Trichloride Arsenic Acid 20% Butyl Alcohol Calcium Nitrate
Chlorinated Lime Paste Chrome Alum Chromic Acid 20%
Citric Acid 40% Copper Chloride Copper Sulphate Cuprous Chloride Formic Acid 10%
Formalin 30% Glycerine Heptane
Hydrochloric Acid 10%
Hydrogen Peroxide 30%
Hydrofluoric Acid 10% Isopropanol
Lactic Acid 20% Magnesium Chloride Magnesium Sulphate Manganese Sulphate Mercuric Chloride Nickel Sulphate Nitric Acid 10%
Nitric Acid 20% Oleic Acid Oxalic Acid Pentane
Phosphoric Acid 10% Potassium Bromate

Potassium Bromide Potassium Nitrate Potassium Perchlorate Potassium Permanganate
Potassium Persulphate Potassium Sulphate Silicone Oil
Silver Nitrate Sodium Bicarbonate Sodium Bisulphate Sodium Carbonate Sodium Chlorate
Sodium Chloride Sodium Hypochlorite Sodium Sulphate Stannous Chloride Sulfur
Sulfuric Acid 10%* Sulfuric Acid 50%
Tartaric Acid 30% Zinc Chloride Zinc Sulphate

Industrial Petroleum Products:
Axle Oil Compressor Oil
Diesel Oil Kerosene Refined Oil Spindle Oil Transformer Oil
Vacuum Pump Oil

Common Household Materials:
Beer
Borax

Cocoa Cement Chocolate Cod Liver Oil Cognac Coffee
Detergents (nonionic and anionic)
Fish Oil
Fruit Syrup Grapefruit Juice Gypsum
Joy Liquid Detergent Insulating Tape Linseed Oil

Liquor Milk
Mineral Water Mustard
Olive Oil Onions Orange Juice Paraffin Oil Rapeseed Oil Rum
Salad Oil
Salt Solution 10% Soap (soft and hard) Table Vinegar Tincture of Iodine 5% Tomato Juice
Vodka Washing Soap Water
Wine

Sulfuric acid 1% attacks polycarbonate
Makrolon has limited resistance to:

Anti-freeze Calcium Chloride Cyclohexanol Ethylene Glycol

Hydrochloric Acid (concentrate)
Milk of lime (CaOH) Nitric Acid (concentrate)

Sulfuric Acid (concentrate)

Makrolon is not resistant to:

Acetaldehyde
Acetic Acid (concentrate) Acetone
Acrylonitrile
Ammonia Ammonium Fluoride
Ammonium Hydroxide Ammonium Sulfide Benzene
Benzoic Acid Benzyl Alcohol Brake Fluid Bromobenzene Butyric Acid
Carbon Tetrachloride Carbon Disulfide
Carbonic Acid

Caustic Potash Solution 5% Caustic Soda Solution 5% Chlorothene Chlorobenzene
Cutting Oils Cyclo Hexanone Cyclohexene
Dimethyl Formamide Ethane Tetrachloride Ethylamine
Ethyl Ether
Ethylene Chlorohydrin Formic Acid (concentrate) Freon (refrigerant & propellant)
Gasoline Lacquer Thinner Methyl Alcohol

Nitrobenzene Nitrocellulose Lacquer Ozone
Phenol
Phosphorous Hydroxy Chloride
Phosphorous Trichloride Propionic Acid
Sodium Sulfide Sodium Hydroxide Sodium Nitrate Tetradydronaphthalene Thiophene
Toluene Turpentine Xylene

Makrolon is dissolved by:
Chloroform Cresol

Dioxane

Ethylene Dichloride

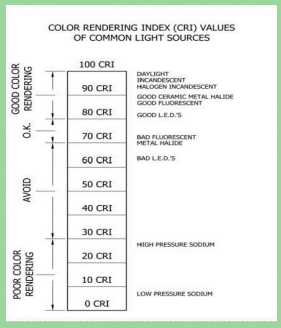
Methylene Chloride Pyridine

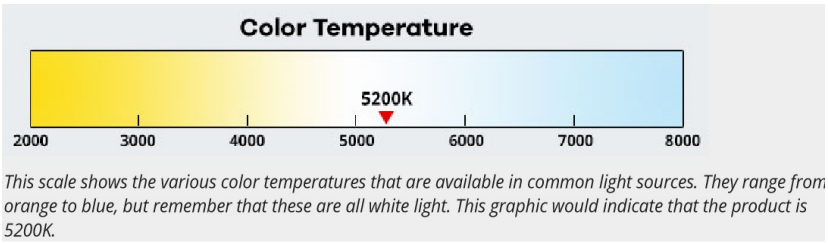
In general, Makrolon sheet has good resistance to water, organic and inorganic acids, neutral and acid salts and aliphatic and cyclic hydrocarbons. Alkalines, amines, ketones, esters and aromatic hydrocarbons attack Makrolon. Solvents for Makrolon are: methylene chloride, ethylene dichloride and dioxane

This chemical and solvent resistant listing is intended to assist designers in determining whether Makrolon sheet can be used in certain environments. It is very important to test prototypeparts under end-use conditions for final verification of performance. All data is based on 70^{0}F and 0% strain.
Makrolon sheet has good resistance to water up to approximately 150^{0}F Above this temperature, the effect of moisture is time-temperature related. Exposing Makrolon sheet to repeated steam cleaning or dish washing can create hydrolic crazing. The result can be a clouding of the surface and ultimately a loss of physical strength properties.

ALLPLASTICS

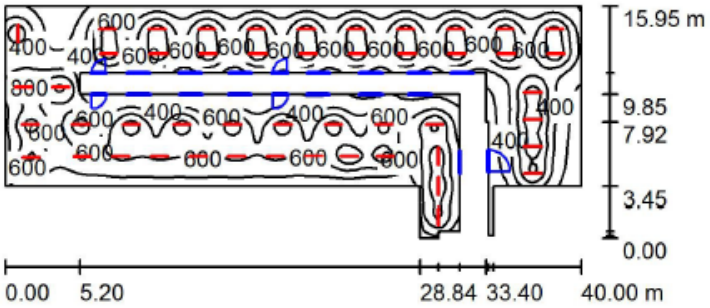
7.2 Appendix 2

<table>
<tr><th>Specification</th><th>Unit</th><th>Example</th><th>Product code or numeric identifier of manufacturer and product</th></tr>
<tr><td>Efficiency Output</td><td>lm/cw</td><td>150</td><td>Efficiency is a measure of how efficiently a luminaire uses power to produce usable visible light. It is the ratio of luminous flux to power and is expressed as lumens/Watt (lm/W). Note that this value should be the amount of Light that is emitted from the fixture after all other loses.</td></tr>
<tr><td>IP rating</td><td>IP</td><td>IP67</td><td>
<table>
<tr><th colspan="2">Degrees of protection against solid objects</th></tr>
<tr><td>IP0X</td><td>Non-protected</td></tr>
<tr><td>IP1X</td><td>50mm diameter and greater</td></tr>
<tr><td>IP2X</td><td>12.55mm diameter and greater</td></tr>
<tr><td>IP3X</td><td>2.5mm diameter and greater</td></tr>
<tr><td>IP4X</td><td>1.0mm diameter and greater</td></tr>
<tr><td>IP5X</td><td>Dust-protected</td></tr>
<tr><td>IP6X</td><td>Dust-tight</td></tr>
</table>
<table>
<tr><th colspan="2">Degrees of protection against water</th></tr>
<tr><td>IPX0</td><td>Non-protected</td></tr>
<tr><td>IPX1</td><td>Vertically falling water drops</td></tr>
<tr><td>IPX2</td><td>Vertically falling water drops with enclosure tilted</td></tr>
<tr><td>IPX3</td><td>Spraying water</td></tr>
<tr><td>IPX4</td><td>Splashing water</td></tr>
<tr><td>IPX5</td><td>Water jets</td></tr>
<tr><td>IPX6</td><td>Powerful water jets</td></tr>
<tr><td>IPX7</td><td>Temporary immersion</td></tr>
<tr><td>IPX8</td><td>Continuous immersion</td></tr>
</table>
</td></tr>
<tr><td>Impact Protection</td><td>IK</td><td>IK09</td><td>
<table>
<tr><th colspan="9">Degrees of protection against external mechanical impacts</th></tr>
<tr><td>IK00</td><td>IK02</td><td>IK03</td><td>IK05</td><td>IK06</td><td>IK07</td><td colspan="2">IK08</td><td>IK09</td><td>IK10</td></tr>
<tr><td>Non-protected</td><td>0.2J</td><td>0.35J</td><td>0.5J</td><td>0.7J</td><td>1J</td><td>2J</td><td>5J</td><td>10J</td><td>20J</td></tr>
</table>
</td></tr>
<tr><td>Warranty</td><td>years</td><td>7</td><td>Warranty is a voluntary promise and is a measure of a manufacturer’s confidence that the luminaire will achieve an expected life.</td></tr>
<tr><td>Lifetime</td><td>L70</td><td>>150,000</td><td>L70 means that no more than 30% of the diodes will fail. The lifetime number of hours is based on the time until this L70 will be reached. KraftigLED fixtures are all conservatively rated. This figure is ascertained during the LM80 test but does not take into account for the loses and additional heat build up for the board and housing etc. Rated life is based on standard test conditions and then there are compensation calculations that are industry standard for test conditions. Some manufacturers try to exclude the compensation calculations to make their product look better. We can review any LM80 certs if their is contention.</td></tr>
<tr><td>Wattage</td><td>W</td><td>40</td><td>The total input power of a luminaire is a measurement of all power consumed by the LED, the driver and the internal electronics. Also known as light circuit power (LCP).</td></tr>
<tr><td>Lumen Output</td><td>lumens</td><td>6000</td><td>Total light output of a luminaire (measured in lumens). Not to be confused with the light output of the LED light engine which invariably is greater than the light output of the luminaire. Note that this value should be the amount of Light that is emitted from the fixture after all other loses.</td></tr>
<tr><td>Driver</td><td></td><td>Meanwell</td><td>An LED driver or power supply provides a similar function as a ballast does for a fluorescent or HID lighting system or a transformer used in a low voltage bulb. The driver regulates the power and provides the LED lighting system with the right amount of electricity to perform optimally. The driver is both a transformer and a convertor of AC power to DC power.</td></tr>
<tr><td>Weight (kg)</td><td>kg</td><td>3.6</td><td>The total weight of the fitting without packaging.</td></tr>
<tr><td>UGR</td><td></td><td></td><td>UGR (Unified Glare Rating) is a method of calculating glare from luminaires, light through windows and bright light sources.
The UGR rating helps to determine how likely a luminaire is to cause discomfort to those around it. For example the discomfort that a LED Panel will cause the work force within an office. This classification ranges from 5 to 40, with low numbers indicating low glare. Preferred ratings Warehouses <25, Offices etc <19.</td></tr>
<tr><td>CRI</td><td>ra</td><td>CRI: >85ra (high colour rendering allows for unlimited use)</td><td>CRI is a measure of the colour appearance of objects. The higher the CRI, the better the quality of the light. CRI is given as a scale ranking up to 100.
A CRI of >85ra or higher is used in most indoor applications. KraftigLED can offer up to >97ra for special applications
 
</td></tr>
</table>

CCT (K)	**K**	4000K (2700K - 6500K)	If you asked for Amber lighting, this is just 2000K. Offices are a maximum 0f 4000K with warm white being 3000K  *This scale shows the various color temperatures that are available in common light sources. They range from orange to blue, but remember that these are all white light. This graphic would indicate that the product is 5200K.*
Lens		Chemical & fire Resistant V0 (Tpa) LED optimised High Haze PC Lens	A lens is an optical device that refracts light, converging or diverging the beam
Power Factor		> 0.95	Measurement of the relationship between the AC source voltage and current. Power factors can range from 0 to 1.0, with 1.0 being ideal. Power factor is sometimes expressed as a percent. "High" power factor usually means a rating of 0.95 or greater. It affects the harmonic of the power supply and is a lose of power efficiency
Extreme Working Temp Range	***C**	- 40*C to + 60*C	Operating temperature range. This becomes important as to the make-up of the light design. If the light design has he light running at a higher ambient temp difference (i.e. KraftigLED aim to run at a 5*C raise in temperature) then the running temperature of a light can go above the operating conditions which will cause a loss of efficiency, faster depreciation of the diode and premature failure.
Flicker Rate	**%**	< 3%	The strobing of some luminaires that cannot be visually detected because of the frequency of its output voltage.
Lumen Deprecation @ 6000 hr @ 55*C	**%**	< 1%	The process where the lumen output reduces over time is referred to as lumen depreciation. While LED and fluorescent technology tend to last longer, they still lose brightness over time. Lumen depreciation can be accelerated depending on lighting conditions such as heat and incorrect voltage. Operating temperature range. This becomes important as to the make-up of the light design. If the light design has he light running at a higher ambient temp difference (i.e. KraftigLED aim to run at a 5*C raise in temperature) then the running temperature of a light can go above the operating conditions which will cause a loss of efficiency, faster depreciation of the diode and premature failure.
Surge Protection		> 5000kVA	A suitable protection device upstream of the electronic LED drivers is a safe barrier against surge voltages. This guarantees the lifespan of the LED luminaires, securing the investment.
LM79-08		Yes	It measures an LED luminaire or integral lamp as a whole system according to a standard process using specified equipment. The testing report issued according to a standard format will provide – Total Luminous Flux – Luminous Intensity Distribution – Electrical Power Characteristics – Luminous Efficacy (calculated) – Color Characteristics (CRI, CCT…)
LM80-08		Yes	It is the Illuminating Engineering Society of North America (IESNA) approved standard for measuring lumen maintenance of LED light sources. LM-80-08 apply to the LED package, array, or module alone, not a complete system, it is testing a component level. The standard does not provide guidance for extrapolation of testing results. The testing report issued according to a standard format will provide luminous flux for a given current over a 6,000 hours period with interval measurements. Luminous flux will be measure for 3 different LED case temperatures: 55ºC, 85ºC and a third temperature to be selected by manufacturer. Besides, the lumen maintenance, the chromaticity shifts over the measured period.
TM21-11		Yes	It is the Illuminating Engineering Society of North America (IESNA) approved method for taking LM-80 data and making useful LED lifetime projections. The standards apply to lifetime projection of LED package, array or module alone. The results can then be used to interpolate the lifetime of an LED source within a system (luminaire or integrated lamp) using the in-situ LED source case temperature. There is not such a thing as testing, it is a mathematical method based on LM-80-08 collected data. Among other thing, TM-21-11 will consider: – If total LM-80 data period is between 6,000 and 10,000 hrs, we consider the last 5,000 hours – If total data period is above 10,000 hours, we use the last half of collected data – In situ case temperature interpolation using Arrhenius equation between LM-80 temperature – Projections are limited to 6 times the available LM-80 data period so projected and reported lifetime may or not be the same
ISTMT		Yes	It is the measure of the LED source case temperature within the LED system (luminaire or lamp). Put simply, it is the temperature of the LED within the luminaire. The measurement has to be performed according to the temperature measurement point (TMP) indicated by the LED package manufacturer. Once ISTMT is known, we check if the temperature within the luminaire is within the temperature of the LM-80-08 LED source report. It is then the basis for lifetime interpolation either based on TM-21-11 or other method.

7.3 APPENDIX 3 – LIGHTING DESIGN

Sheep Floor / Normal Lighting / Summary



Height of Room: 3.590 m, Maintenance factor: 0.70 — Values in Lux, Scale 1:500

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	532	5.68	979	0.011
Floor	20	480	11	699	0.022
Ceiling	70	90	5.68	123	0.063
Walls (20)	50	187	2.69	774	/

Workplane:

Height:	0.800 m
Grid:	128 x 128 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.307, Ceiling / Working Plane: 0.169.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	28	KraftigLED ltd Linear-45w LED Harsh Area Linear 1200mm 45w (1.000)	7511	7512	48.9
2	21	KraftigLED ltd Linear-45w LED Harsh Area Linear 1200mm 45w (1.000)	7511	7512	48.9
			Total: 368053	Total: 368064	2396.1

Specific connected load: 5.25 W/m² = 0.99 W/m²/100 lx (Ground area: 456.54 m²)