P08428 LED Lighting Technologies for a Sustainable Entrepreneurial Venture

Performance Review

May 9, 2008

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Performance Review Agenda

Meeting Purpose (Review technical specifications of the design and compare to customer needs)

Materials to be Reviewed (*experimental tests*)

Meeting Date: May 9, 2008

Meeting Location: 09-4425

Meeting time (*8:30am-10:00am*):

Timeline (*in table below indicate start time for each activity, the topic of review, and the required attendees*):

Meeting Timeline		
Start time	**Topic of Review**	**Required Attendees**
8:30	Introductions	Everyone
8:35	High-Level Project Summary (Presentation)	Everyone (Shawn)
8:55	Design requirements (Hand out)	Everyone
9:20	Improvements tasks remaining	Everyone (Shawn)
9:30	Mechanical Drawing Package (Appendix A)	Everyone (Taylor)
9:40	Electrical Drawing Package (Appendix B)	Everyone (Phil)
9:50	Questions	Everyone

High-Level Project Summary

Project #	Project Name	Project Track	Project Family
P08428	LED Lighting	Sustainable Products, Systems, and Technologies Track	Sustainable Technologies for the RIT Campus
Start Term	**Team Guide**	**Project Sponsor**	**Doc. Revision**
072	Dr. Stevens	FMS (unconfirmed)	A

Project Description

Project Background:

RIT is dedicated to environmental issues and sustainability. This project entails developing a product that will conserve electrical energy, and reduce Maintenance costs. It was found from project P07421 that off-the shelf LED light fixtures are inadequate.

Problem Statement:

Current exterior lighting technologies are resource intensive and not electrically cost effective. RIT spends about $6 million per year in electrical costs, which half is due to lighting. RIT also dedicated a large portion of resources in the maintenance of exterior lighting. A newly designed LED replacement kit will be easily implemented in existing light fixtures.

Objectives/Scope:

1. Reduce energy usage.
2. Reduce maintenance costs.
3. Create a marketable end product.
4. Gain experience with LED lighting system design.

Deliverables:

- Scalable lighting product prototype to accept multiple voltage inputs.
- Life cycle report.
- Return on investment.
- Budget.
- Plan for commercialization (Finish in SDII).
- Drawing plan.
- Manufacturing plan.
- Conference paper.
- Technical poster.

Expected Project Benefits:

- Design feasibility has been determined at the end of SDI.
- Prototype and plan for implementation has been accomplished at the end of SDII.
- Expected energy and cost savings to RIT.
- Improve RIT's image by reducing its global footprint.
- RIT gains experience in alternative lighting systems.

Core Team Members:

- Shawn Russell
- Christine Lagree
- Taylor Shivell
- Arthur Deane
- Philip Pietrantoni
- David Eells

Strategy & Approach

Assumptions & Constraints:

1. Current shoebox fixture will be used.
2. Use of Light Emitting Diodes (LED).
3. LED performance is comparable to current lighting systems.
4. LED's will be more cost effect over its lifetime.
5. Lighting system decreases maintenance costs.
6. The new lighting system will be safe and durable to outdoor conditions.
7. The new lighting system will be compatible with the existing power grid.
8. The light output must be measured at 1-2 a minimum of ft-candles at the ground along walkways.
9. Lighting system conforms to all safety regulations and electrical standards.
10. Easily manufactured.
11. CRI higher than that of HPS lamp.
12. Color temperature is between 3000K and 5400K.
13. Use common parts amongst fixtures.

Issues & Risks:

- Have not obtained funding.
- Adequate light distribution might not be possible with current LED technology.
- Adequate light intensity might not be possible with current LED technology.
- Incoming power might not be easily converted to usable source for LED lighting.
- Design for 30 years could be expensive.
- Cost of materials and manufacturing.
- Product might not be easy to install.
- Timeframe for completion is small.
- Resources might not be available.
- Product may not have a favorable market outlook.
- Environmental considerations (manufacturing and use).
- Systems integration.

Customer Needs

Need No.	Subsystem	Need	Importance
1	Fixture and light	Conform to regulations put in place by OSHA, IEEE, UL and EPA	9
2	Fixture and light	Use less energy than existing systems	3
3	Fixture	Be recyclable	1
4	Fixture and light	Be sustainable	3
5	Light	Decrease the light pollution that the existing lights create	1
6	Fixture	Standardize parts within the fixtures	9
7	Light	Color Temperature comparable to Metal Halide	9
8	Fixture	Be easy to install and replace lights	3
9	Light	Provide as much light as current systems	9
10	Light	Spread the light out	9
11	Light	CRI higher than that of HPS lamps	9
12	Fixture	Aesthetically pleasing	1
13	Fixture and light	Decrease energy bill	3
14	Fixture	Keep fixture price low	3
15	Fixture and light	Decrease the amount of time and money maintenance spends on the system	9
16	Light	Bulbs are recyclable	1
17	Fixture and light	Provide a product that can be easily manufactured	9
18	Fixture and light	Economically viable	9
19	Fixture	Be vandal resistant	3
20	Fixture	Have a long life span	9
21	Light	Have a long life span	9
22	Fixture	Withstand the elements of the outdoors	9
23	Fixture	Weight	9

Target Specifications

Metric No.	Need Nos.	Metric	Imp.	Units	Marginal Value	Ideal Value
1	1	Complies with applicable codes and regulations	9	Binary	Yes	Yes
2	2,4	Power consumption	6	W	<130	<50
3	2,4,9,10	Power efficiency	24	lm/W	>30	>70
4	3,4,16	Percent by weight of product recyclable	5	%	70%	100%
5	4	CO_2 Emissions	3	Pounds	850	500
6	12	Luminance	2	ft-cd	??	??
7	6,8	% of common parts used in fixtures	12	%	>50	>70
8	7, 12	Color Temperature	10	K	3000-5400	4100
9	8,18	Install Time	12	hr	<3	<1
10	8,15,18	Maintenance time per “ticket”	21	hr	<2	<1
11	8,23	Weight	12	lbs	<50	<30
12	9,10	Light density at edge of coverage area	18	ft-cd	0.5	1
13	9,10	Light spread (length)	18	ft	30-40	40
14	9,10	Light spread (width)	18	ft	3-5	4
15	7,9,11,12	CRI	28	unitless	>65	>80
16	9,10,12	Aesthetically pleasing (Survey 1-5)	19	unitless	>3	>4
17	13,18	Energy usage	12	kWhr/month	<65	<18
18	14,18	Fixture cost	6	$	<700	<500
19	4,14,18	Disposal cost	7	$	10-100	50
20	14,17	Manufacturing cost	12	$/unit	<400	<250
21	4,13,18	Pay-back Time	15	years	<15	<7
22	2,4,13,15,18	Total Savings per fixture	27	$/yr	>40	>60
23	19	Pass Drop & Vibration tests	1	Binary	Yes	Yes
24	4,18,20,22	Fixture lifetime	30	years	>25	>30
25	4,18,21	LED lifetime	21	hours	50,000	100,000
26	22	Operating Temperature	9	*F	-10 - 110	-30 - 130
27	22	Maximum Temperature range	9	*F	>140	>150
28	15	# of maintenance “tickets” in lifetime	9	tickets	<5	0
29	3,4	Life-cycle cost	4	$	<1000	<500
30	18,13	Return on Investment	12	%	>0	>10

Design Requirements and Results

1.) Complies with applicable codes and regulations:
The fixture has been designed to meet National Electric codes as well as IEEE codes. All wire gages comply with NEC codes using 18AWG for the transformers because they are using 1.67A max (18AWG is rated up to 2.32A), and (.918max for 24AWG which were running to each board), each board requires 400mA; complies with NEC codes.

2.) Power consumption is less than current system:
A test was conducted to find the actual power being consumed by the LED light fixture. The fixture passed the test with a total consumption of 60watts. Each LED board uses 10.8W. This provides a TOTAL of 60W for our system including power lost due to the transformer. This meets the customer specification of using less than the current system's 165W power usage.

3.) Power efficiency
Our system is has an efficiency of 76%.

4.) Percent by weight of product that is recyclable
This value is still to be determined.

5.) CO_2 Emissions reduction
Since the decision was made to continue running the light fixtures off of RIT's grid as opposed to running of other alternative energy sources, the only way to reduce emissions was to reduce energy consumption. With the reduction in energy consumption from 165 W per fixture to 60 W per fixture, annual CO_2 emissions were reduced from 857.7 lbs/kWh to 311.89 lbs/kWh per fixture. This meets our ideal value of being less than 500 lbs.

6.) Luminance
The light characteristics will be determined through a survey. The survey includes questions directed toward color temperature, brightness and CRI. The results will be compiled and will be used to improve future designs.

7.) Percent of Common parts used in fixtures
The only variation in the materials is the use of lenses. Different sizes will be placed on the boards depending on their placement in the fixture. The percent of common parts is greater than 80%. This meets our ideal value of being greater than 80%.

8.) Color Temperature
Our system meets the customer's specification of a natural white light with a 4100K color temperature as specified by the supplier.

9.) Install Time
A test on the 5-board model is to be completed on Friday, May 9.

10.) Maintenance time per "ticket"

A test on the 5-board model is to be completed on Friday, May 9.

11.) Weight

The replacement kit weighs less than the current Metal halide fixture, and therefore conforms to the EPA ratings.

12.) Light density for entire coverage area

Alpha prototype: Failed objective due to collimating lens not meeting manufacturer's specifications; redesign carried out using reflectors in place of lenses. Manufacturing difficulties require use of new lenses from another source to test Beta prototype. Viewing angle on new lenses theoretically will allow proper light density.

Beta prototype: Testing to be carried out Friday, May 9.

13.) Light spread (length)

Alpha Prototype: Light spread over 80' length of walkway segment achieved using directional placement of LEDs and lensing system. Actual spread is longer along this axis, allowing dimmer areas to benefit from overlap from other fixtures.

Beta Prototype: Testing to be carried out on Friday, May 9.

14.) Light spread (width)

Alpha Prototype: Light spread over width of walkway achieved using directional placement of LEDs, including 10° tilt of overall fixture backplate, coupled with lensing system to reduce light spread off of walkway area.

Beta Prototype: Testing to be carried out on Friday, May 9.

15.) CRI

LEDs were chosen to provide desired CRI. According to the datasheet, the CRI for the CREE LEDs is 75, which is our ideal value.

16.) Aesthetically pleasing

The light characteristics will be determined through a survey. The survey includes questions directed toward color temperature, brightness and CRI. The results will be compiled and will be used to improve future designs.

17.) Energy usage

This is based on our power consumption of 60Watts per fixture operating 12 hours per day for 30 days. The energy usage is determined to be 0.36kWhr/month. This is within specification.

18.) Fixture cost

The fixture cost will be greater than $213.93 when labor and external costs are included. Common practice is to double the manufacturing cost, which puts the commercial fixture cost at greater than $430. At this time, this value is meeting our ideal value of less than $500.

19.) Disposal cost

This value is still to be determined, but most parts are recyclable resulting in a low disposal cost.

20.) Manufacturing cost

The cost of materials for one fixture is $213.93. Approximate labor costs and external costs still need to be calculated for future commercialization. At this time, our fixture is meeting our marginal value of $400.

21.) Pay-back period

The pay-back period equals the initial investment/annual savings. The initial investment is $470 and the annual savings is $64.39. The pay-back period is 7.3 years. This value meets our marginal value of less than 15 years.

22.) Total savings per fixture

Total savings includes labor, energy, and material savings. Total annual savings per fixture are $64.39. This value meets our ideal value of savings greater than $60.

Energy Costs

Total Annual Energy Cost (LED)	$15.77
Total Annual Energy Cost (MH System)	$43.36
Total Annual Energy Savings	$27.59

MH Material & Labor Costs

MH Lamp Annual Cost Savings	$24.00
MH Ballast Annual Cost Savings	$12.80
Total Annual MH Material/Labor Savings	$36.80
Annual Savings	$64.39

23.) Vibration test

A vibration test was conducted to simulate an impact to the light pole. Calculations indicated a low frequency oscillation of 0.9Hz would occur to the lighting fixture upon first impact to the base of the pole. The pole would then damp out to a higher frequency and shorter oscillations. The test was conducted to simulate extreme conditions that had a range of frequencies from 3 Hz to 100 Hz with a force of 0.7G. The LED lighting system continued to operate under these conditions without any LED's extinguishing resulting in a successful test.

24.) Fixture lifetime

The customer specified a design of the fixture to be 30 years minimum. We did not change the current fixture and therefore met our customer specification by default.

25.) LED lifetime

LED lifetime has been estimated at 50,000 hours based on the suppliers' data sheet. A duration test to prove this specification is not possible with the amount of time assigned to this project.

26.) Operating Temperature

Two tests were conducted to verify operation in low and high temperatures. The low temperature test subjected the fixture to -30°F for one hour. The high temperature test subjected the fixture to 150°F for one hour. Both tests were as success. It is however recommended to operate the fixture over 140°F ambient conditions; otherwise lifetime of the LED's will degrade.

27.) Maximum Temperature range

Two tests were conducted to verify operation in low and high temperatures. The low temperature test subjected the fixture to -30°F for one hour. The high temperature test subjected the fixture to 150°F for one hour. Both tests were as success. A climate test was also conducted to observe the effects of extreme environmental conditions on the light fixture. This included a 95% relative humidity at 150°F. The test was interrupted on the third day since we experienced a transformer failure due to a malfunction of the cooling system on the environmental chamber. A transformer that supported three LED boards was damaged, but the second transformer continued to power the other two LED boards. It is believed that if the malfunction of the environmental chamber did not occur, then the fixture would have passed the 7 day climate test. Further testing should be conducted to verify this assertion.

28.) Number of maintenance "tickets" in lifetime

The lifetime of the fixture is 30 years. The rated LED lifetime is 50000 hours or 11.4 years at an average of 12 hours daily usage. The boards will be replaced 2.6 times over 30 years. Based on lamp life alone, this meets our marginal value of less than 5 tickets.

29.) Life-cycle cost

The lifetime of the fixture is 30 years. The total costs include material costs, labor costs, and energy costs. Total investment over the fixture's lifetime is $1,818.32. This exceeds our marginal value of $1000. At the time we created our specifications, we did not take all costs into account, and therefore the target values are not realistic.

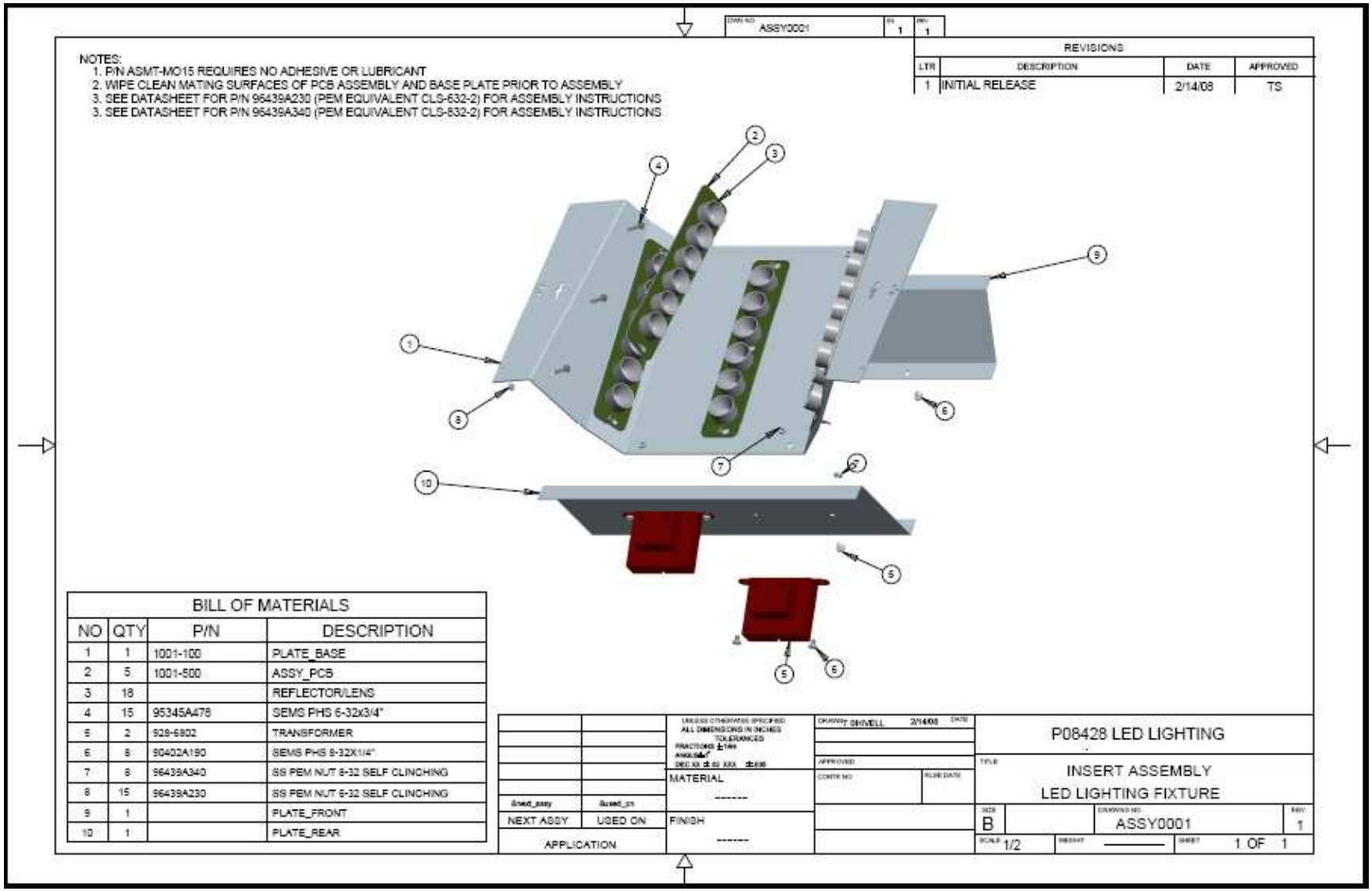
30.) Return on Investment

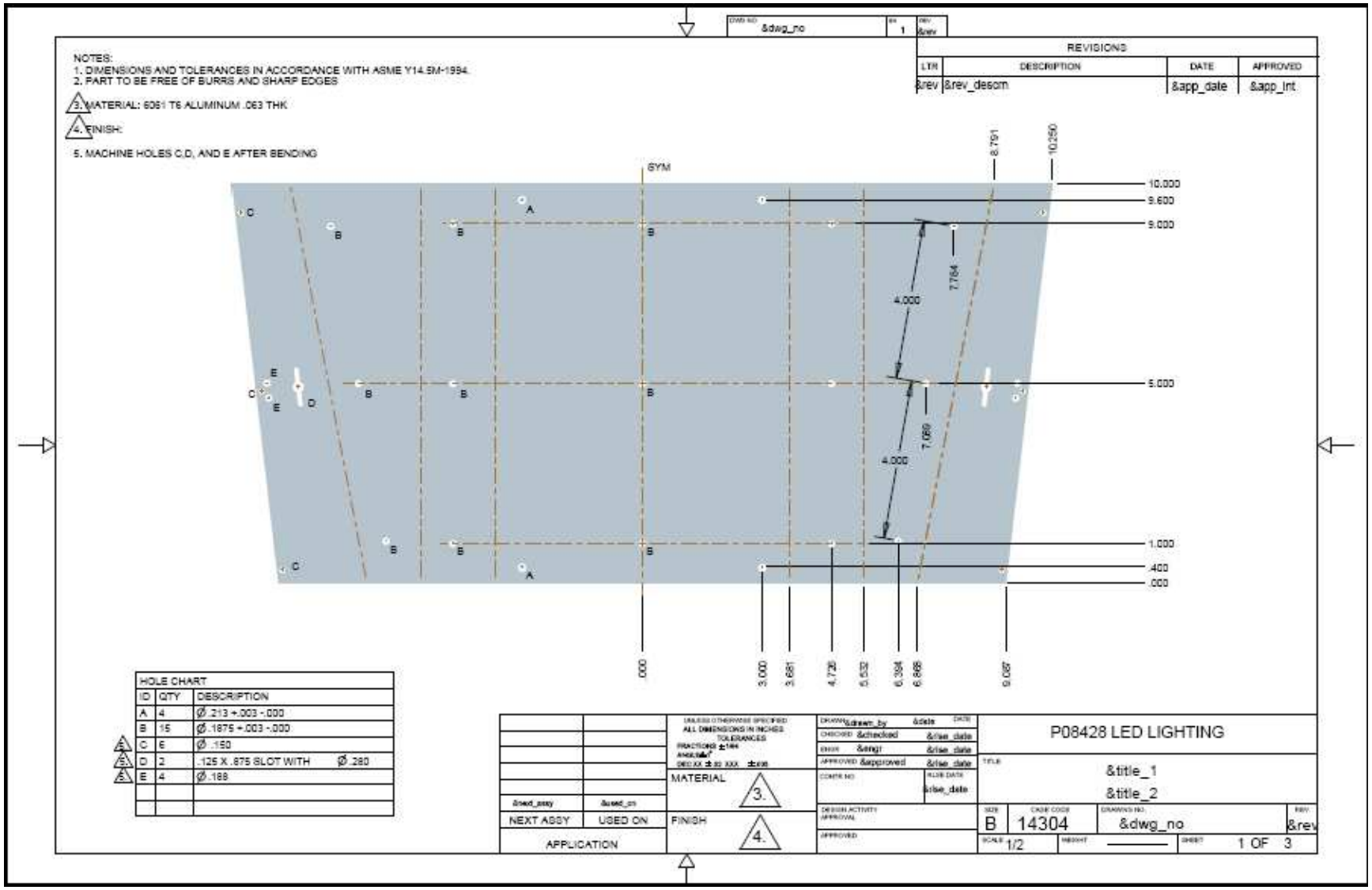
The return on investment equals the annual savings/initial investment. The annual savings is $64.39 and the initial investment is $470. The return on investment is 13.7%. This value meets our ideal value of greater than 10%.

Improvements & tasks remaining

1.) Installation of two fixtures
2.) LED lighting survey needs to be conducted after installation of two fixtures.
3.) Climate testing should be conducted to determine the extreme environmental operating conditions.
4.) Testing of light density of Beta Prototype, both in dark room and in installation location.
5.) Testing of light spread of Beta Prototype, both in dark room and in installation location.
6.) Replacement testing of Beta prototype.
7.) Retrofit testing of Beta prototype.

Appendix A (Mechanical Drawing Package)

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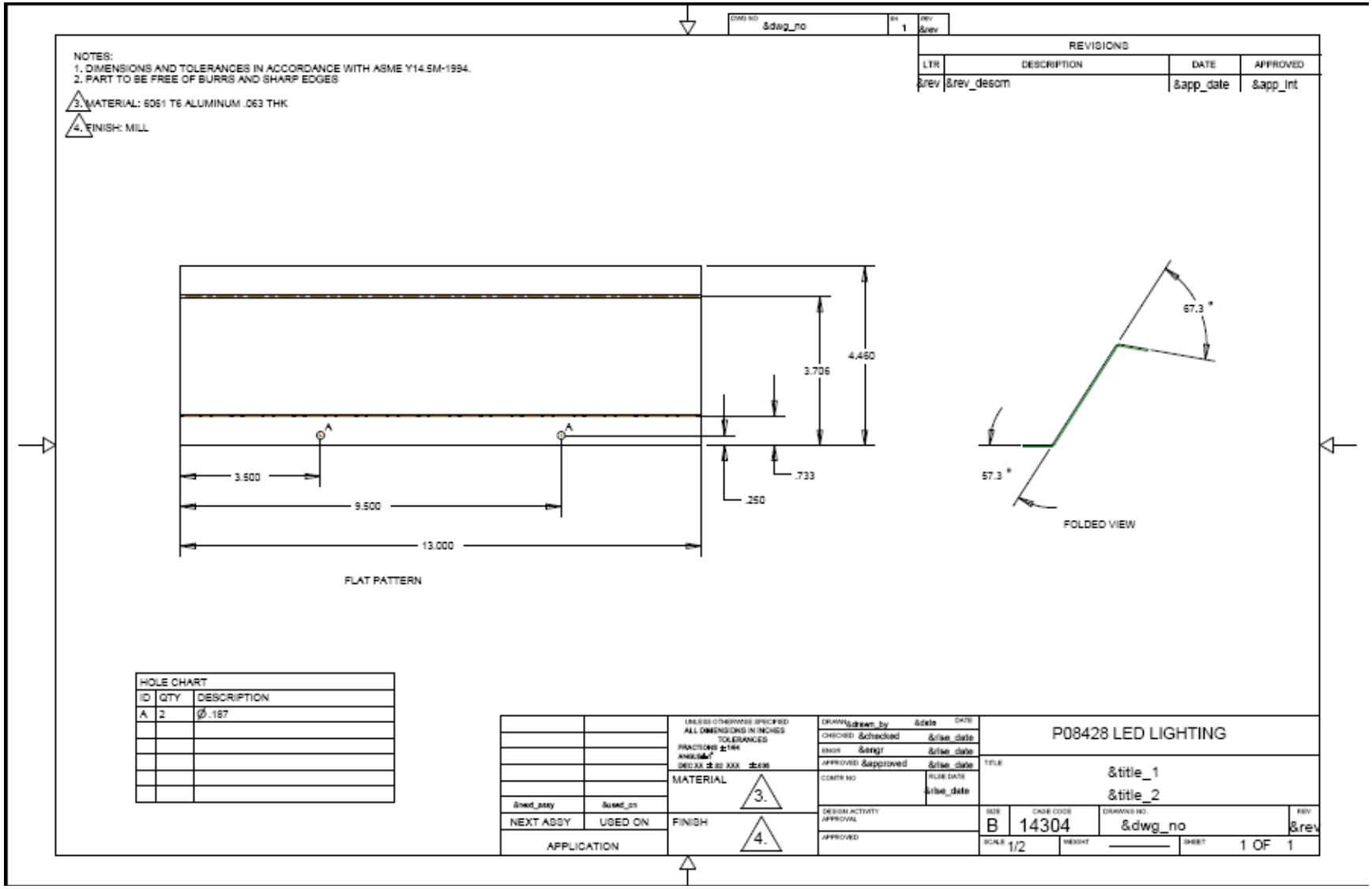
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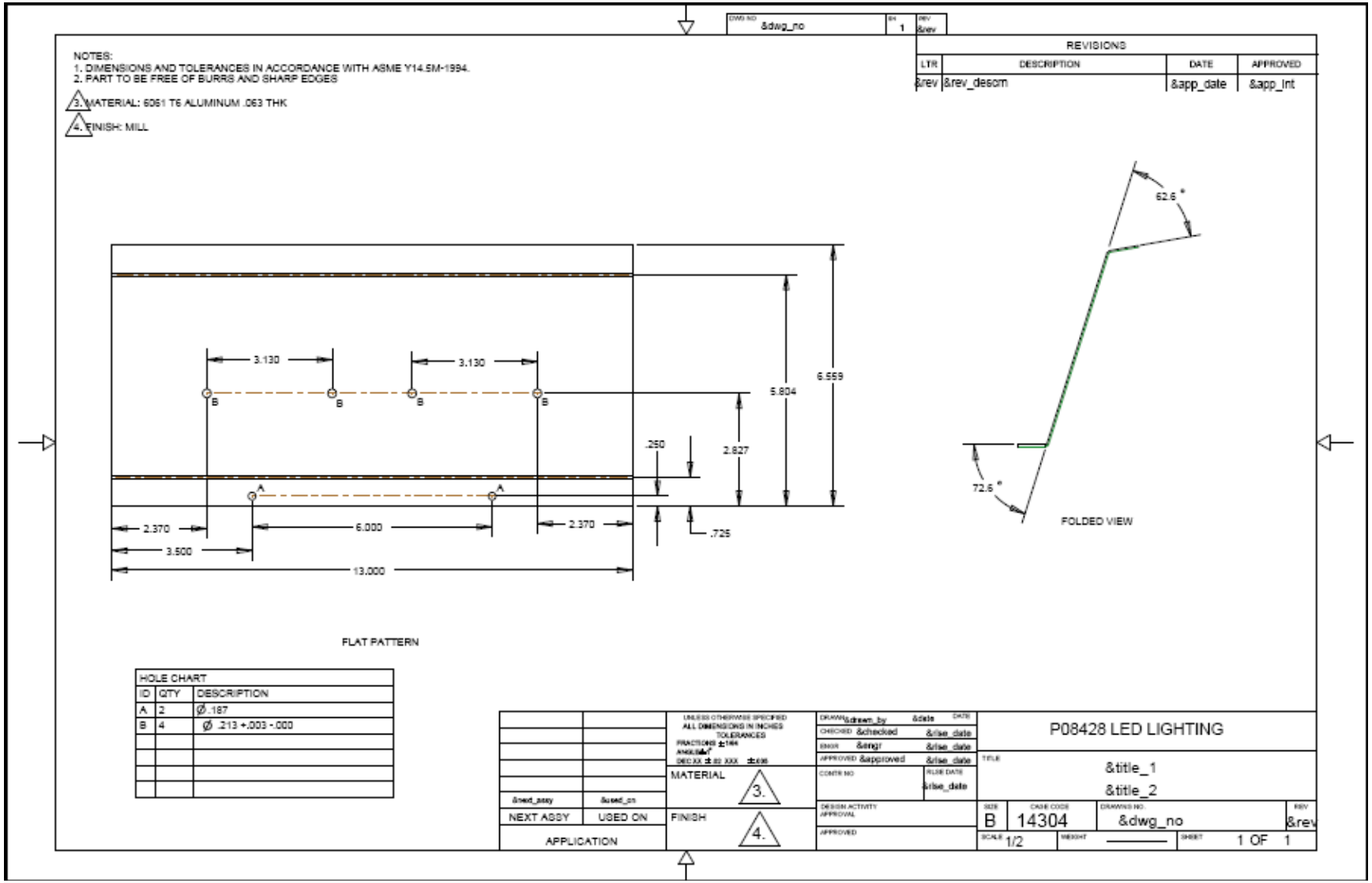
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FOLDED VIEW
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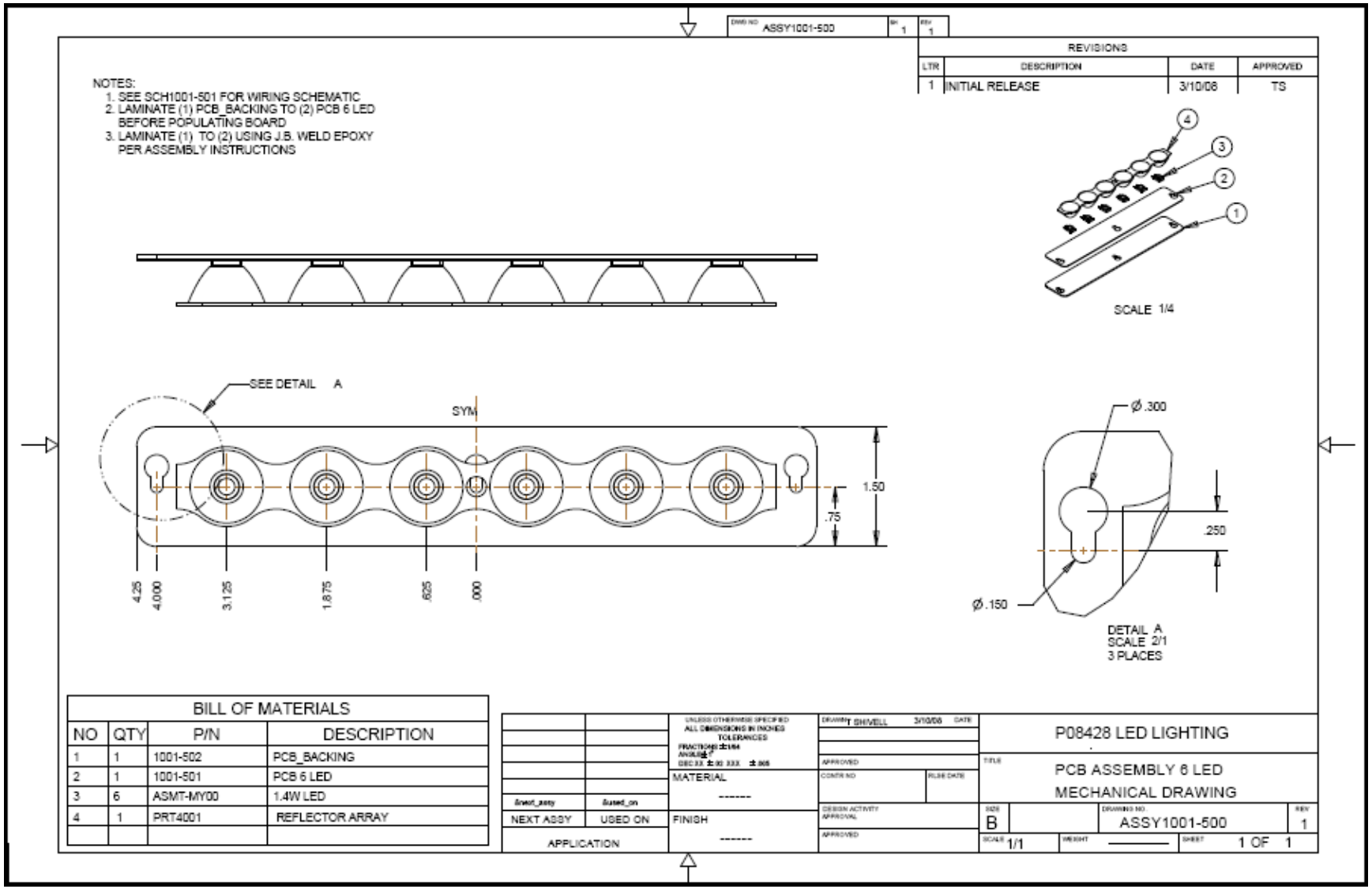
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3 6 ASMT-MY00 1.4W LED
4 1 PRT4001 REFLECTOR ARRAY
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APPLICATION
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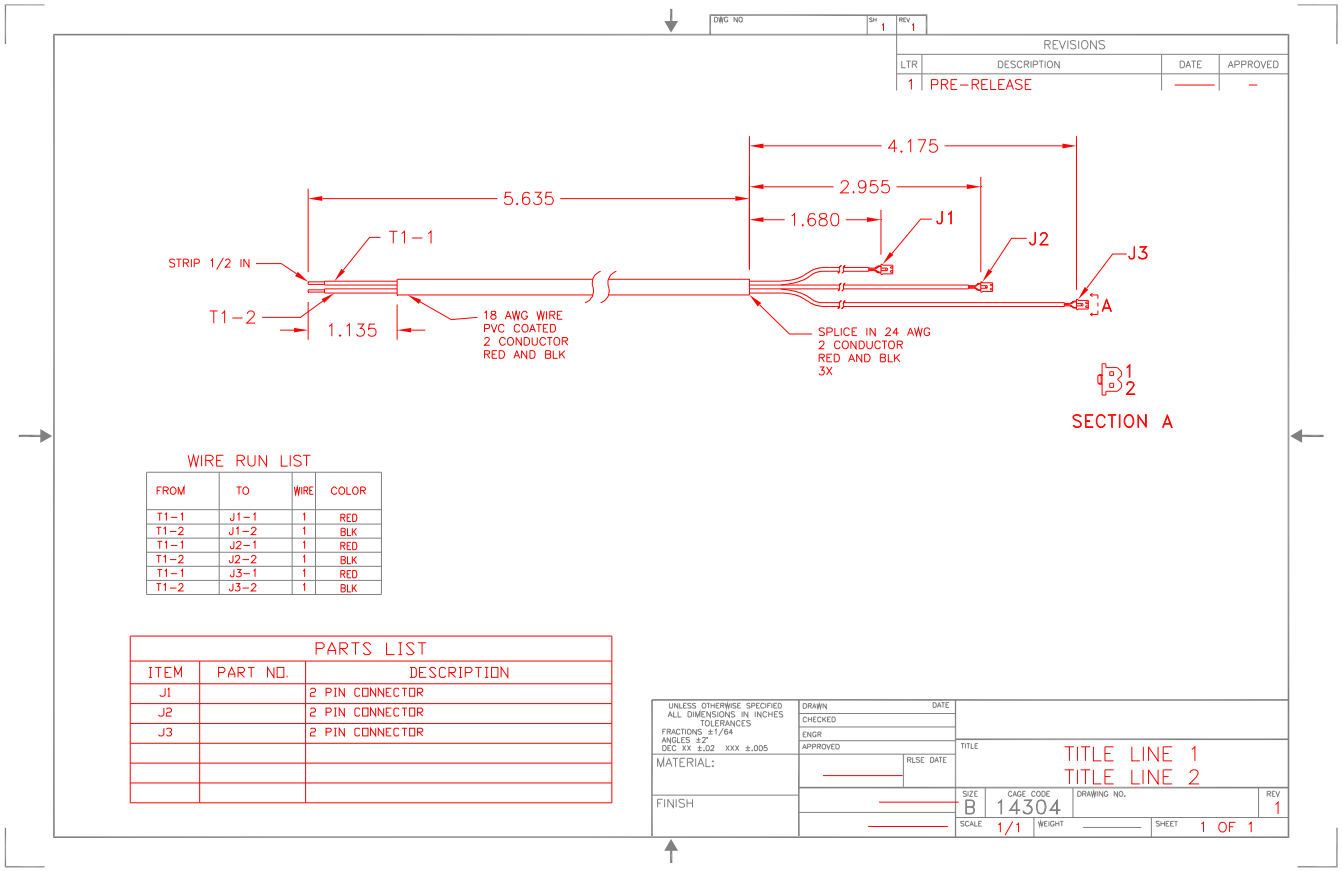
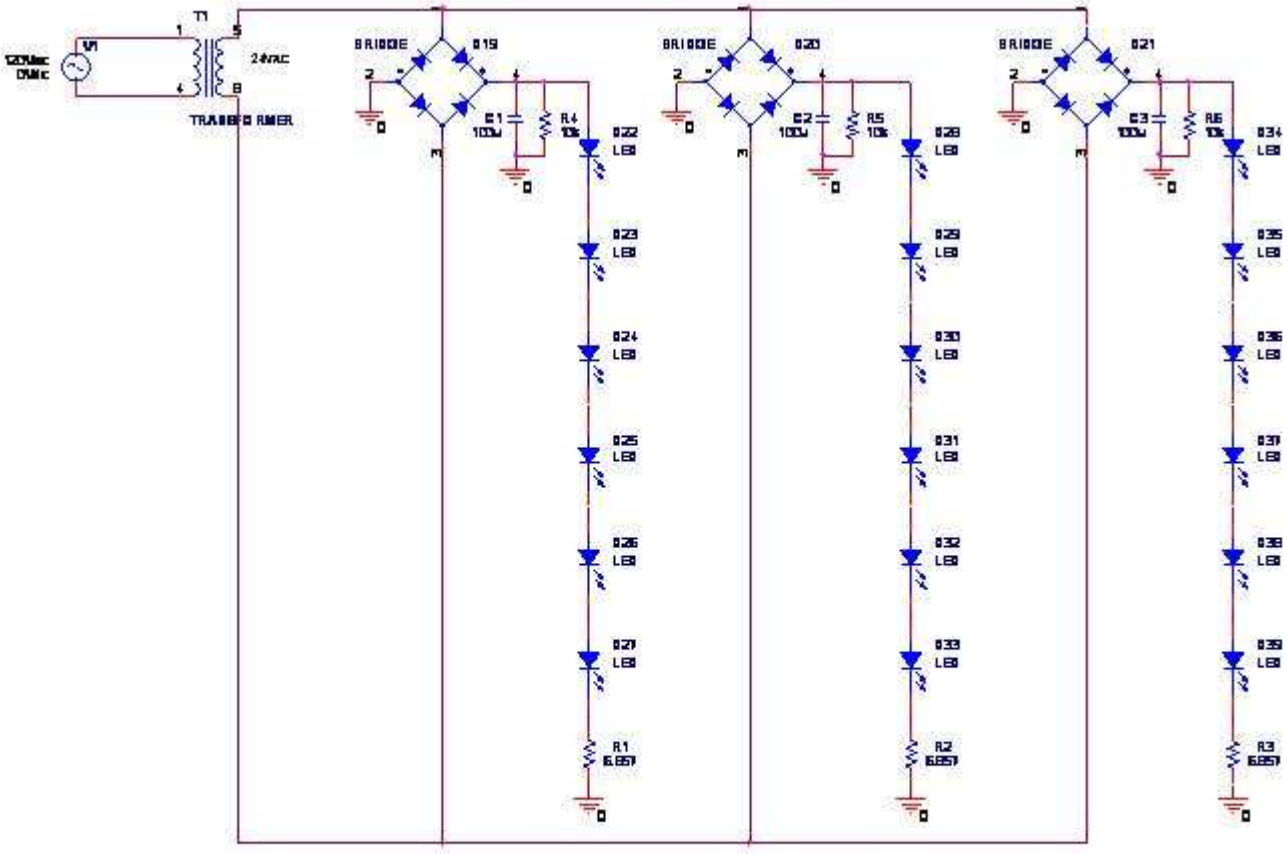
SCALE 1/1
SHEET 1 OF 1

Appendix B (Electrical Drawing Package)

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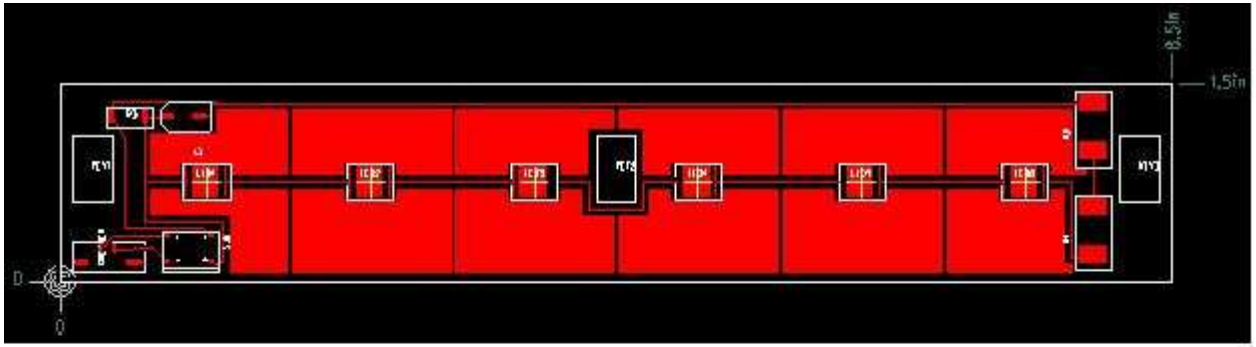
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