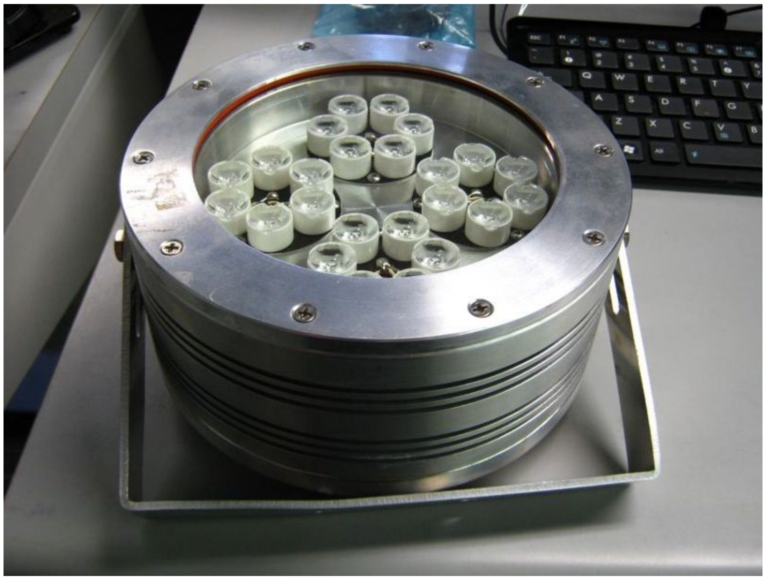
Extreme Temperature Testing



January 27, 2012

Notes:

1) Our temperature/humidity chamber can only control humidity between approximately 25°C-85°C. We cannot do a thermal cycle beyond this range while controlling the humidity. I would suggest that we do a simple temperature cycle between -55°C -105°C for 1000 hours, followed by an 85°C/85%RH test for another 1000 hours.
2) The chamber being used is an ESPEC BTX-485.

1. Proposed Test Plan for Nemalux XCANLEDDC device
    a. Test Plan: Temperature cycle (approx. 42 days)
        i. Prior to fixture being loaded into the chamber, several digital photos of the UUT
           will be taken, noting any visual defects, or apparent discolorations. Power will be applied to the UUT to ensure that the unit is functioning normally.
        ii. UUT will be loaded into chamber, power will applied via the programmable power supply, the chamber will be sealed, and the time of

such will be noted. The thermal cycling will begin by moving to the high temperature of 105°C at a target rate of 2°C/min. Once the UUT has reached 105°C the temperature will be held for 45 minutes to allow the entire unit to stabilize in temperature. The UUT power will then be turned off for a period of 10 minutes, at which point, the power will be turned back on to simulate high-temperature turn-on events. It will be left on for approx 5 minutes. The temperature will then be commanded to reduce to -55°C, again at a target rate of 2°C/min where the low temperature will again be held for 45 minutes, before removing system power. After a period of 10 minutes, the power will be reapplied to simulate low-temperature turn-on. This pattern will continue until 1000 hours of time have elapsed. It is estimated that a single cycle will take approx. 280 minutes, meaning that the device will undergo approximately 214 cycles. Voltage and current values from the digital power supply will be logged throughout the test.

iii. After 1 week, preliminary data will be reported to the client. Each day, the device will be checked to ensure that the system is still functioning normally (by inspecting whether the power is still being properly applied). After 1000 hours (or when there has been a failure), the chamber power will be removed, and the time of such noted. The UUT will be left for 4 hours, to allow for the unit to come to standard conditions, and a second visual inspection will be conducted. Digital images will be taken, and any apparent differences between the beginning and end points will be noted.

b. Test Plan: Thermal soak/Steady state life: High temperature (1 day)

   i. The UUT will be returned to the chamber, and the DC power supply will be attached via the communications aperture in the chamber. The time of such will be noted.

   ii. The temperature will be commanded to rise to 105°C, and will be left for a period of 24 hours. Every 2 hours, the power will be cycled either off or on, so that for the first 2 hours, power will be applied, the following 2 hours, power will be off, and will continue like this until 24 hours has been reached. Voltage and current values from the digital power supply will be logged throughout the test.

   iii. After 24 hours have elapsed, power will be removed from the chamber, and the UUT will be left for a period of 4 hours, so that the unit can come to atmospheric conditions. A third visual inspection will be done, and differences due to the high temperature exposure will be noted.

c. Test Plan: Thermal soak/Steady state life: low temperature (1 day)
    i. The UUT will be returned to the chamber, and the DC power supply will be attached via the communications aperture in the chamber. The time of such will be noted.
    ii. The temperature will be commanded to lower to -55°C, Every 2 hours, the power will be cycled either off or on, so that for the first 2 hours, power will be applied, the following 2 hours, power will be off, and will continue like this until 24 hours has been reached. Voltage and current values from the digital power supply will be logged throughout the test.
    iii. After 24 hours have elapsed, power will be removed from the chamber, and the UUT will be left for a period of 4 hours, so that the unit can come to atmospheric conditions. The UUT will be powered up, so as to determine whether it is operating properly. A fourth visual inspection will be done, and differences due to the low temperature exposure will be noted.

d. Test Plan: Water-immersion freeze/thaw process (approx 40 hours)
    i. The UUT will be reloaded into the chamber, into a container filled with dyed-water (a few drops of food coloring in the water), and the time of such will be noted.
    ii. The chamber temperature will be commanded to reach -20°C (-2°C/minute), and will be left to soak for approx 3hours and 40 minutes (the device will be inspected after 4 hours to determine whether the contents have completely frozen). The temperature will then be commanded to reach 20°C (at a rate of 2°C/minute), and will be left to soak for approx 3 hours and 40 minutes. The overall cycle time will be approximately 8 hours. This cycle will be repeated 5 times.
    iii. After completion of the freeze-thaw cycles, the system chamber power will be removed, and the unit will be removed from the liquid. The device will opened to inspect whether there is any die staining within the body of the unit, and whether there is any visual damage to the body and o-ring. Power will be applied to the UUT again, to determine whether the unit still functions normally. A fifth visual inspection will be done, and any apparent differences due to the freeze-thaw testing test will be noted.

Information will be collated into a formal report and provided to the client upon completion of the testing.

1. Introduction

Nemalux is a Calgary-based company designing and manufacturing high-durability LED lighting. Nemalux recently engaged ACAMP to study the XCANLEDDC device under various environmental conditions.

2. Test Parts

 As described in Quote 12-NL-0006, the testing proceeded in 4 parts. The first part was a 1000 hour test which cycled temperature between -55°C and 105°C while turning the power to the light fixture off and on again. The second part was a 24-hour high temperature soak, where the device was kept at the temperature of 107°C, and while the power to the device was turned off for 2 hours and then turned back on for two hours, and repeated until test conclusion. The third test was identical to the second test, excepting that the temperature was set to -55°C. The fourth test was to determine the fixture's ability to survive multiple freezing and thawing cycles.

3. Test Results

3.1. Nemalux Part 1A Testing

3.1.1 Scope

This report is to detail Nemalux's temperature part A testing on the XCANLEDDC device. The device was tested for 1000 hours.

Design temperature sweep: -55°C to +105°C, 1000 hours.

3.1.2 Notes About the execution of the Part 1A Test

1. After approx 2 days, the temperature sweep was widened to: -57°C to +107°C in order to ensure that the fixture reaches its target temperatures.
2. After resetting the temperature sweep (after day 2), a single setting was improperly programmed on the current meter. This is why it looks as though there was no current flowing through the device for the period between hours 46 and 70. Once this was noted, the setting was corrected. It should be emphasized that this was only a setting error, and that there was current flowing to the device, as evidenced by visually noting the presence of light coming from the thermal chamber.

3. The system was checked each business day to ensure that proper program execution was occurring. Once the system had finished its 1000 hour program, the fixture was allowed to return to room temperature, and was then inspected, and images of the fixture collected.

3.1.3 Main Outcomes from Part 1A Testing

1. The fixture physically survives the testing, and is capable of operation after the test.l

2. There is evidence of time-dependent performance change throughout the testing, which may be attributable to the temperature cycling, but which may also be natural device ageing.

3. Current draw at +107°C is changing over time, and ranges from approx. 2.43 A (@11.67 V) at the start of test, to approx. 2.45 A (@11.67 V) at the end of the test. This shift is highlighted by red bars overlaid on the data plot shown in figure 1.

4. Current draw at -57°C is changing over time, and ranges from approx. 2.3 A (@11.67 V) at the start of test, to approx. 2.0 A (@11.67 V) at the end of the test. This shift is highlighted by blue bars overlaid on the data plot shown in figure 1.

5. Maximum current draw is 2.95 A at an unknown temperature (@11.67 V).

3.1.4 Detailed Results Information

Figure 1. shows the temperature and current data plotted against time. The trend bars that have been added show time-dependent features of the plot (see points 3 & 4 in “Main Outcome from Testing”). In contrast to the preliminary report, the stable current draw at the low temperature extreme (-57°C) is lower than the stable current draw at the high temperature extreme (107°C); at an unknown temperature between these two extremes, the light fixtures draws a maximum current of approx. 2.95 amps. Figure 2 shows a close-up image of the current and temperature over a reduced time period to highlight important characteristics in the current-temperature relationship. This is a brief description of a single temperature/current period on Figure 2. The numbers correspond to the red numbers on Figure 2.

Power is reactivated after being off at high temperature. An immediately measured current is seen which is changing over time. The current quickly stabilizes at a value of approx. 2.44 A, but as the system starts to heat up due to excess power dissipation, the current lowers by approx 0.01A.

The temperature falls from 107°C down to -57°C. The UUT will thermally lag the chamber ambient temperature, but as temperature falls the current rises. It would seem that there is a peak current which occurs at a temperature somewhere within the operating region (i.e. not at one of the two extreme temps).

The ambient temperature reaches the low value and stabilizes. After 30 minutes, the power shuts off, and the current falls to zero. When the power is reactivated at low temperature, there is an immediately measured current which is changing over time. The measured current quickly tends towards 2.22 A, the approx. stable current at -57°C. The short section of increasing current which is concave down is likely being caused by the temperature increase due to the power dissipation after the unit has been re-energized.

The ambient in the chamber then begins to rise back towards 107°C. The UUT also begins to increase in temperature, and the current subsequently increases until it passes the temperature at which current is maximized (max current is approx 2.94 A, unknown maximizing temperature) and then begins to decrease again. The current drops to a value of approx 2.45 A, which is close to its stable operating current at 107°C.

The power to the unit is then shut off, and the device stabilizes in temperature.

Cycle complete, and repeats.

3.3.4 Detailed Results Information

Figure 7 shows a plot of the collected temperature and device current data against time. The temperature curve is seen to decrease to -57°C, and to hold this temperature until the end of the test. The temperature is then allowed to naturally come back to room temperature. The current increases as the temperature decreases until it reaches a maximum value, and then begins decreasing as the temperature decreases. The power is turned off between hours 3.1 and 5.1, and during this time, the fixture will thermally stabilize at -55°C. When the power is re-applied, then unit begins to create its own heat, and the unit will increase in temperature. The current increases as this occurs. And then stabilizes at the device reaches a stable temperature within the thermal chamber. This stable current, however, seems to decrease over the course of the experiment, beginning at 2.18 amps, and ending at approx. 2.08 amps. This may indicate a form of ageing is occurring, though it is unknown whether it is due to the exposure to an extreme environment, or whether it is a natural form of burn-in ageing.

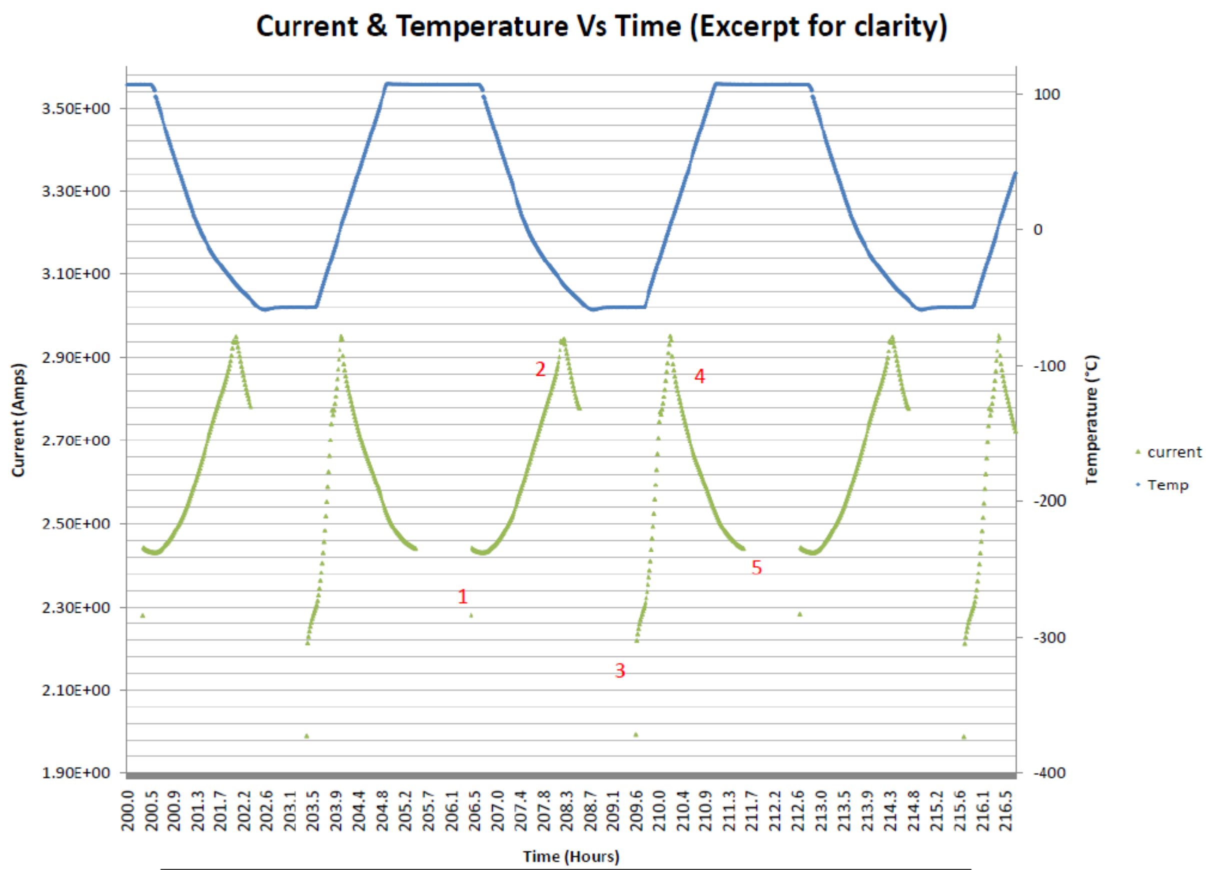
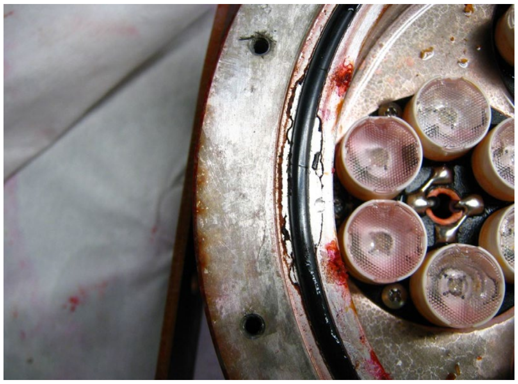


Figure 2. Close-up view of Current and temperature vs time.



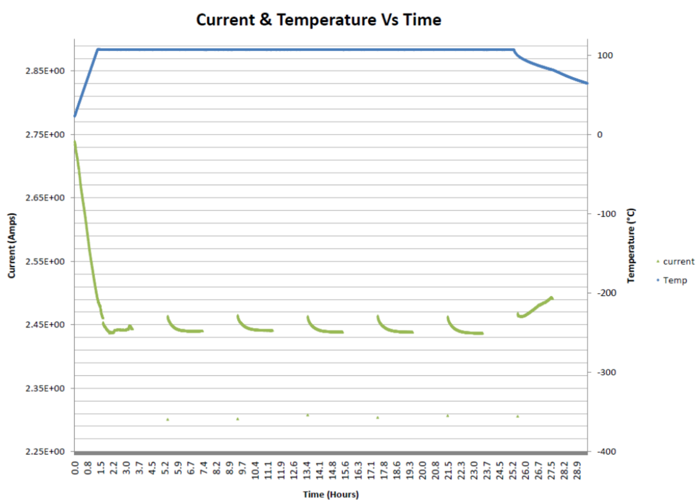


Figure 5. A plot of UUT current and temperature data collected vs time during the Nemalux part 1B test.

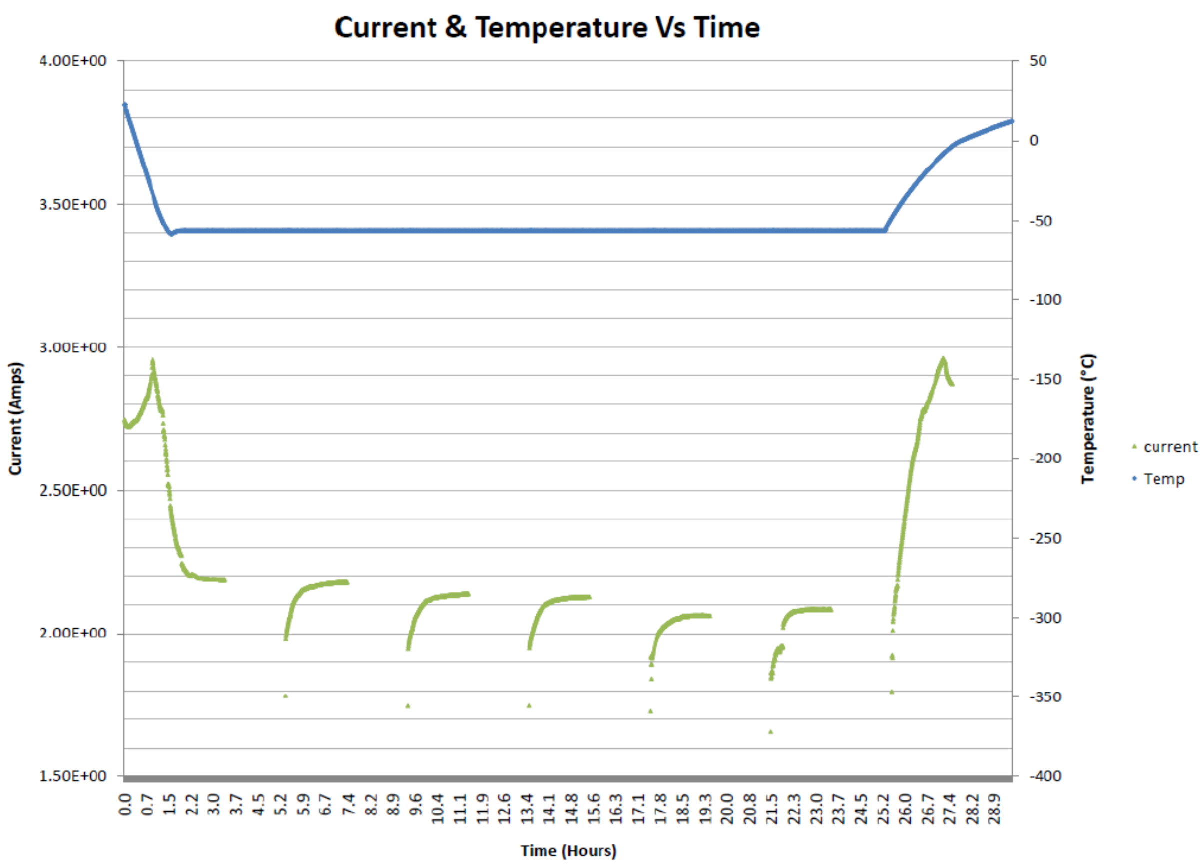
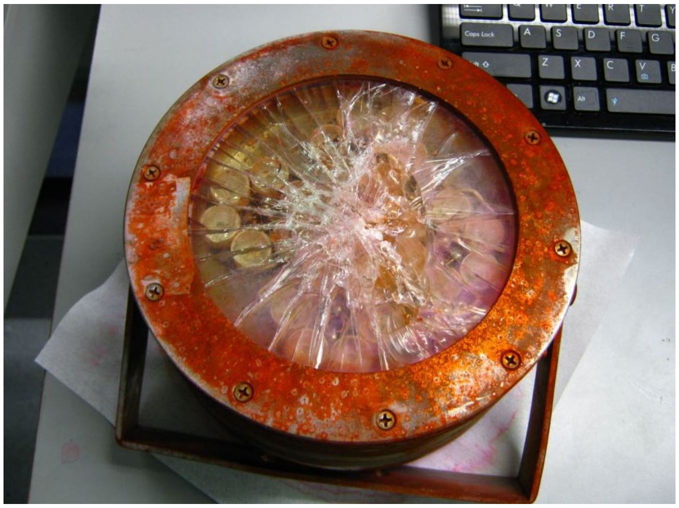


Figure 7. A plot of UUT current and temperature data collected vs time during the Nemalux part 1C test.


Caps Lock
A
S
D
F
G
Z
X
C
V
Alt