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2020 Pixel Survey Report and What we can do about it

Bill Porter

2021.1

Who am I?

- Bill Porter, Electrical Engineer, US Navy
- Embedded design, System engineering, Power systems

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Who are we?

- Official xLights Vendor Group Admins
  - Kevin Lederer
  - Chris Nellis
  - Jonathan Landingham
- One is a fire guy (Chris) B.S. in Fire Science, Worked as a Fire Investigator
- Also talked to epoxy expert
  - Joey Spendlove
- Special Thanks
  - Keith Westley, Daryl Collins, Brian Rudy, John Spiker, Russell McFarland, Jim Gray
  - And everyone that took the survey.

- No financial stake with any vendor. I am friends with multiple vendors.

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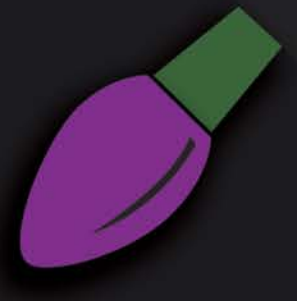
Why did we do this?

- High failure rates and fires appeared to be large problem this year, more so than usual.
- One thing is certain, there was more talk about failures this year.
- Lots of scary pictures of fires.
- Lots of discussion on what was causing them, jumping to conclusions.
- I saw lots of theories with technical problems.
- Could it be user error?



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What we wanted to collect

- Failures only.
- Look for trends or patterns with the failures for clues to the cause.
- Can prove / disprove theories with the data?

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What we didn’t want to collect

- Not the entire pixel community.
- Attempting to correctly capture the entire industry worth of experience would be hard to impossible.
- “Vendor bashing”
  - Used google forms and required a google account tied to each entry to avoid ballet box stuffing.
  - We are only revealing the vendors that showed a statistical difference from the rest.

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What does that mean?

- Things we can say (these are EXAMPLES)
  - All reported fires had rainbow colored epoxy.
  - All high failure rate pixels were Triangle shaped pixels.

- Things we can’t say
  - What percent of rainbow colored epoxy pixels sold end up catching fire.
  - When the rainbow colored epoxy pixels were made or sold.
  - Percentage of good to bad pixels sold by any vendor.
  - If the customer is satisfied with the Vendor’s response.

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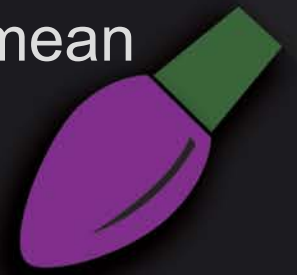
Common sense



- Millions upon millions of pixels have been made with no issues.
- Any vendor can end up selling a bad batch of pixels; and that doesn’t mean previous or future batches will be bad as well.

- Only 102 usable survey results means failure rate is VERY low compared to sales. This also means low sample size.

- Everyone should expect SOME failures, that’s normal.

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Real goal of survey

- Motivate vendors to be more open when they are aware of manufacturing issues caught after the sale.
- Only they can tell us who is affected, when they were sold, etc.

- Turn everyone here into a better educated consumer

- Bust some myths.
- Promote healthier online discussions.

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To be super clear

- I will be presenting data collected through the survey.
- I will be presenting the response from 2 vendors who were shown a summary of the data.
- I will be giving my expert opinion on what I believe the data shows.
  - This includes knowledge gained when consulting with the Epoxy vendor and the Fire analysis expert.
  - I can be wrong.
  - That opinion given under the assumption the survey was answered honestly. (I think it was).
- I will be correcting some theories I've seen with engineering analysis.

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Diving into the Data

- 129 surveys taken
- Reading through all the survey entries, we had to throw some out.
  - 5 didn’t report any failures (loss of one color is not a failure we counted)
  - 9 reported too few failures well below 0.1%
  - 5 were confusing, conflicting information, unclear
  - 8 selected multiple vendors but did not break down failures per vendor
- 102 entries left to consider.

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Diving into the Data

- As we started taking looking at the data in a few different ways, two obvious failures became evident.
- Fires/charring and dead pixels when separated have fairly unique distributions.
- Going to discuss these as two separate sets of data.

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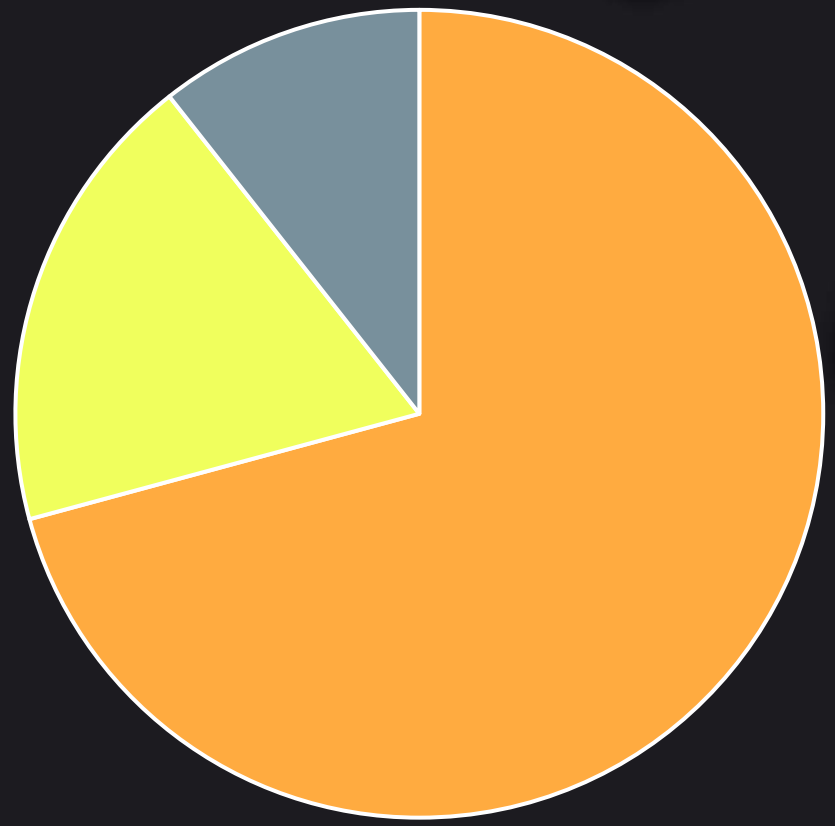
Fires vs. Dead Pixels

- 102 Survey Entries
  - 71% Dead Pixels
  - 18% Fires
  - 11% Charring

- The Fire / Charring datasets looked very similar, so combining them as “Thermal Events”.
- Makes overall issues 70/30 split dead pixels to fires.



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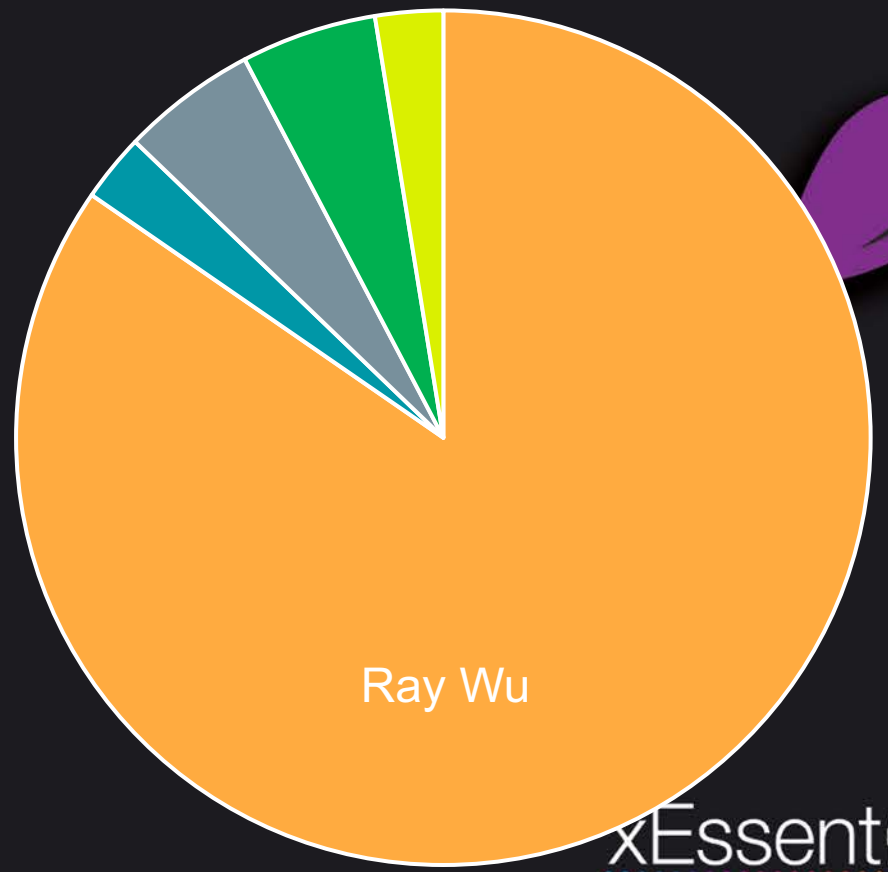
Fires / Charring

- Of Fires / Charring reported.
  - 85% Ray Wu
  - 15% remaining split across 4 other vendors, each no more than 5% individually.
- This is a large enough margin to draw some conclusions.



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To Repeat

- Ray has made millions of good pixels for many years.
- That doesn’t mean he can’t have had a bad batch once or twice.
- I can’t tell you when that batch was sold with any acceptable precision.
- We emailed him and I will show the response.
- I am NOT saying don’t buy from Ray. However if you are concerned, I advise you contact him with your concerns first.
- We can dive deeper for clues.

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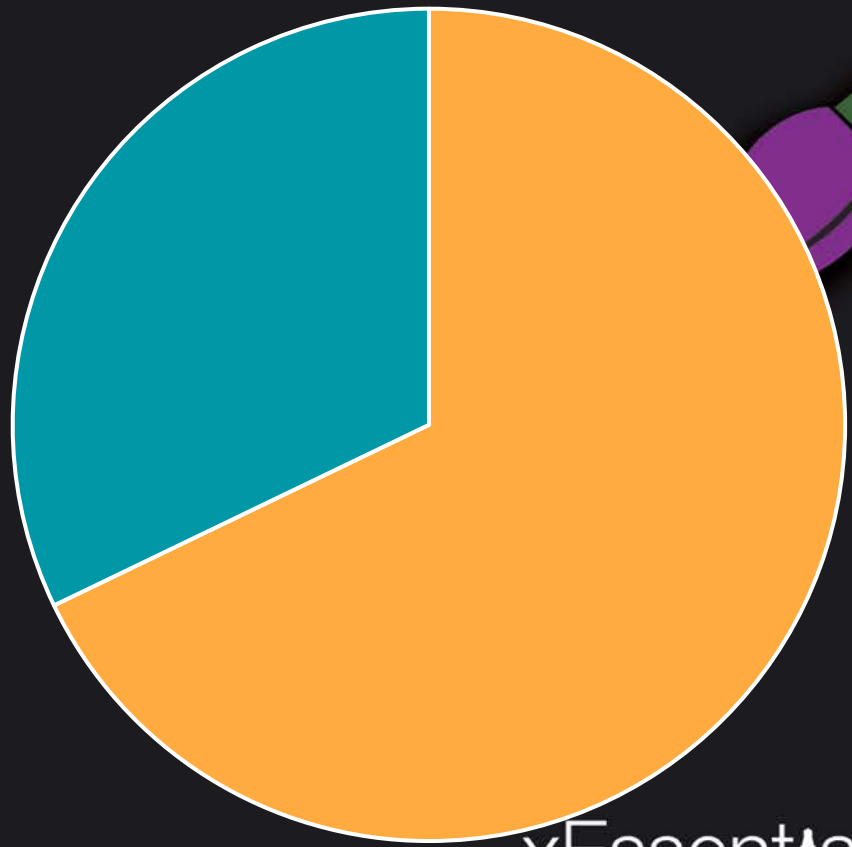
Let’s go deeper

- Pixel Type of Rays Fires / Charring reported
  - 68% Round / Bullet
  - 32% Square

- Round outsells squares, this is likely an even distribution with that considered.
- Both seem affected.



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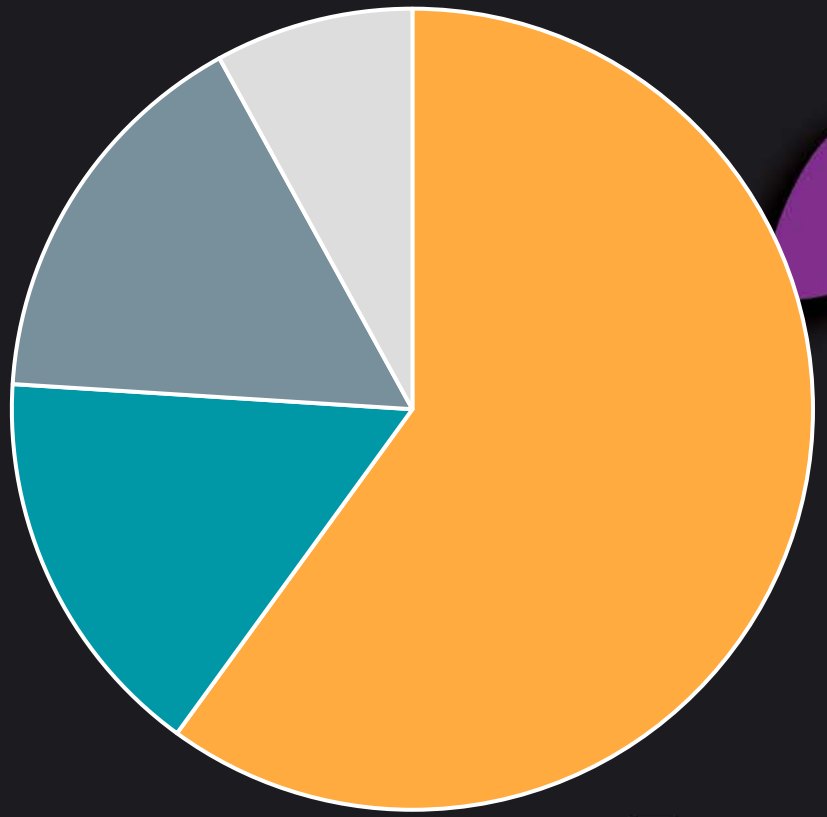
Fires / Charring

- Of Fires/Charring of Ray's pixels reported:
  - 60% 12V regulated
  - 16% 12V unsure
  - 16% 12V resistor
  - 8% 5V
- This is enough of a margin to say it's mostly focused on regulated pixels.



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More Notes

- Many vendors have been selling regulated pixels for years without issue.
- Ray has been selling regulated pixels for years.
- There is nothing inherent to the design of regulated pixels to make them more likely to catch fire. *

- Correct Conclusion: I believe Ray sold a batch of regulated pixels with defective regulators.

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Again

- DO NOT BE AFRAID OF REGULATED PIXELS!

- They produce more consistent color and can run longer without power injection.
- They do NOT get any hotter than resistor pixels.

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Ray Wu Response to email

- most of my customers are smaller ones,also many of them buy from my aliexpress store directly, i sold about more than 6.5 million pixels in 2020, so I guess that was a reason that why it seems that my pixels were with high percentage.
- the regulated pixels has higher failure rate than the resistor type, because the regulated one are designed with a 78L05 regualted, which make the whole pixels to be 0.65W when at full white color,so much more heat than the resistor. also the regulated pixels are with more components than the resistor ones.

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My Thoughts

- The “I sell the most” argument:
  - 85% to 5% the next largest vendor is too significant to explain away with sales volume difference.
  - I asked to few other vendors if they would be willing to share their 2020 sales volume. Most declined, one responded with 4.4 million, but asked to stay anonymous.
    - You have to believe Ray and other vendor are being honest about sales volume.
  - So to me, this disproves the explanation it’s only due to sales volume.

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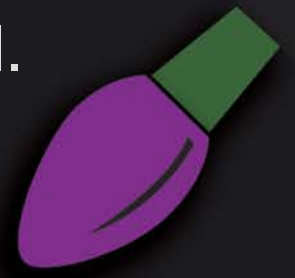
My Thoughts

- The “power” argument?:
  - The LED and driver chip are what sets the power drawn of the pixel.
  - All pixels are about 50mA, 0.25W itself. (Full White)
  - 12V pixels must dissipate another 0.35W as heat
    - This is the same power that has to be dissipated whether through resistor or regulator.
  - I’m assuming Ray’s “0.65W” must be him talking about this extra dissipation, but again, resistor pixels have to do this too. They aren’t magic. Both have to drop voltage from 12V to ~5V for the LED.
  - So I don’t understand this response.



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I believe

- I believe these were just defective regulators that failed to a high impedance short, heated up and in some cases, caught fire.
- Alternative theory that this could be epoxy failure, that lead to corrosion across power leads on regulator that shorted and heated up to fire.
  - We will discuss epoxy failures in a bit.
  - Resistor pixels may not have a place on the PCB where 12V and GND are close (like next to a regulator), so harder to form shorting corrosion to explain why they didn’t fail to fire as much.

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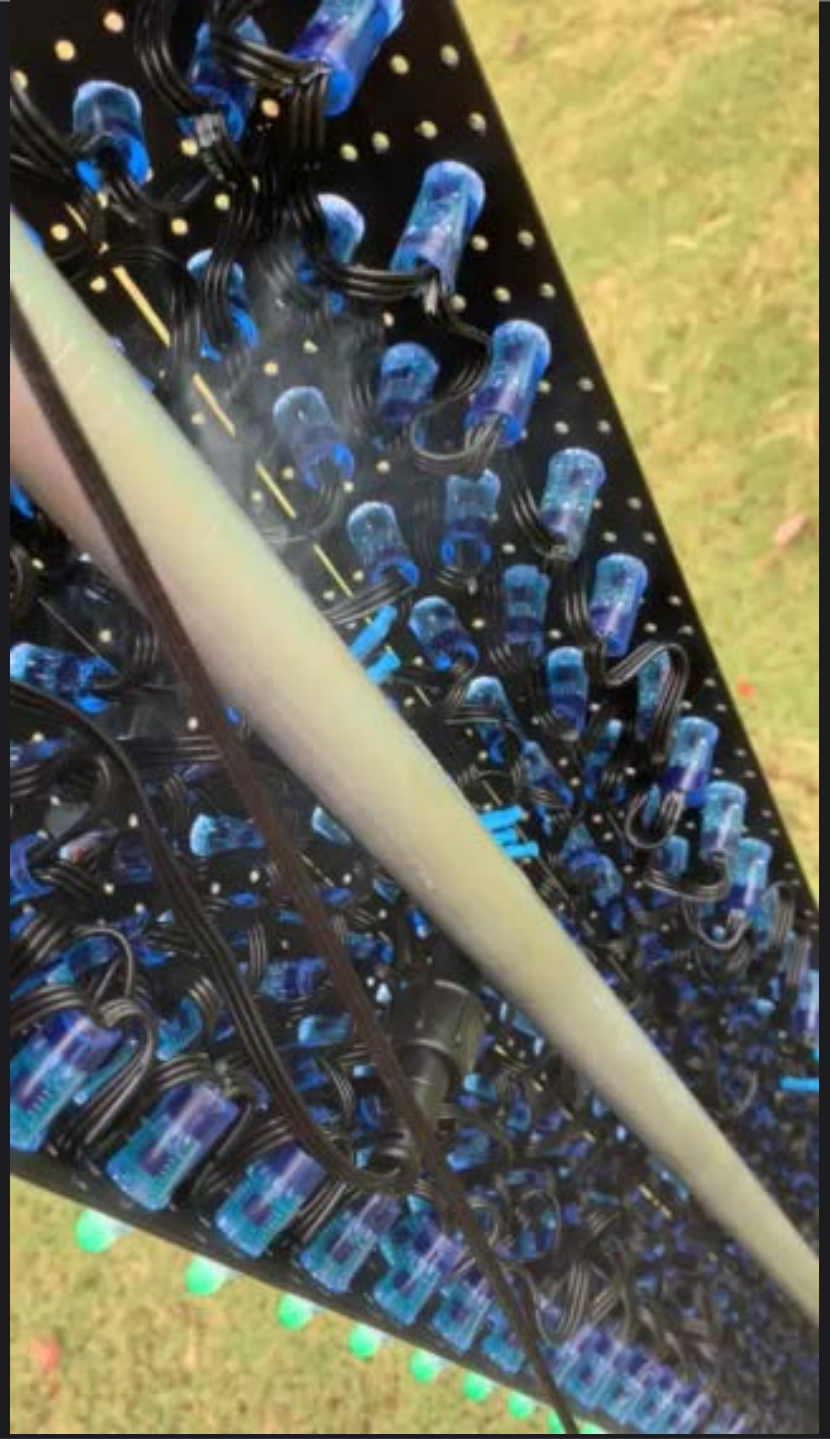

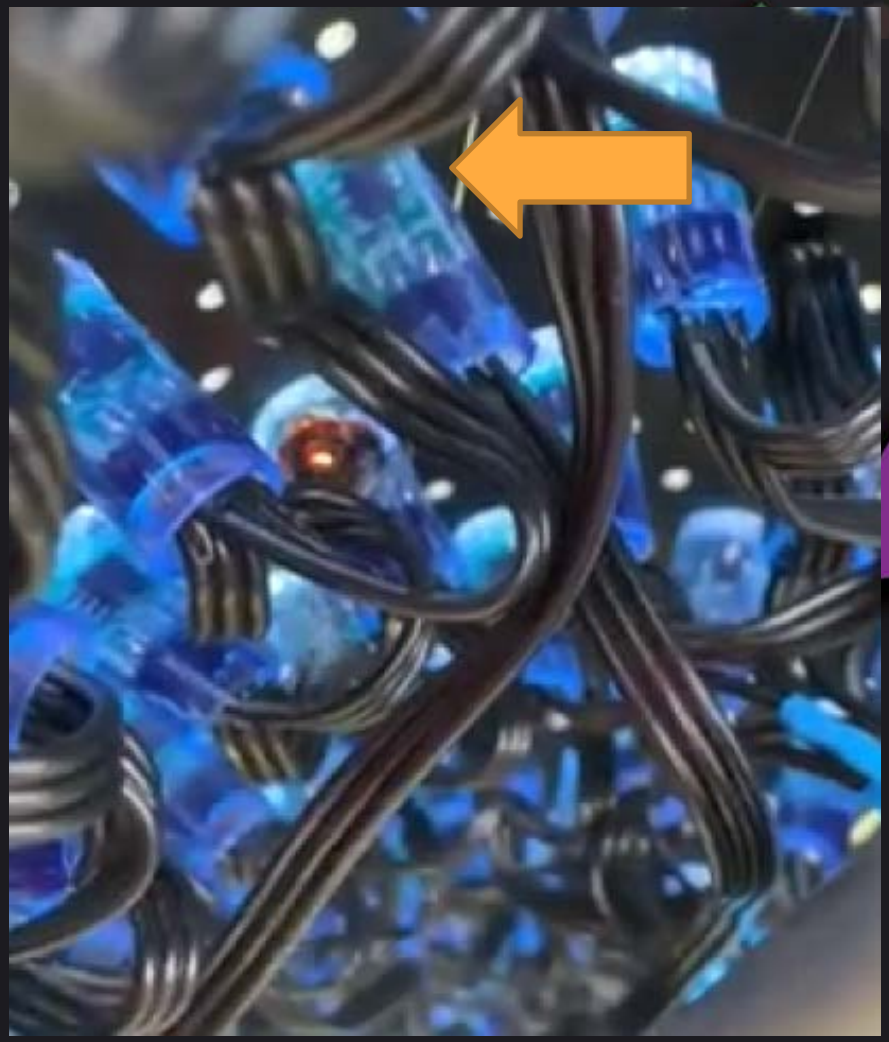

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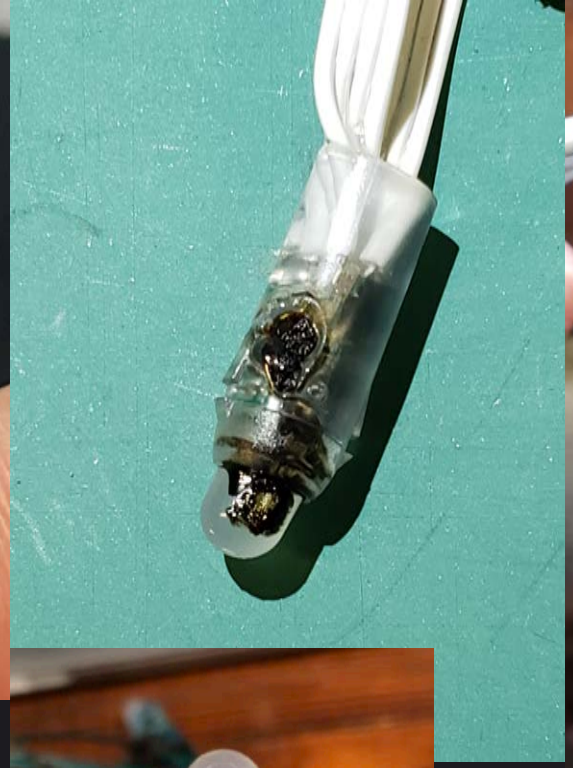

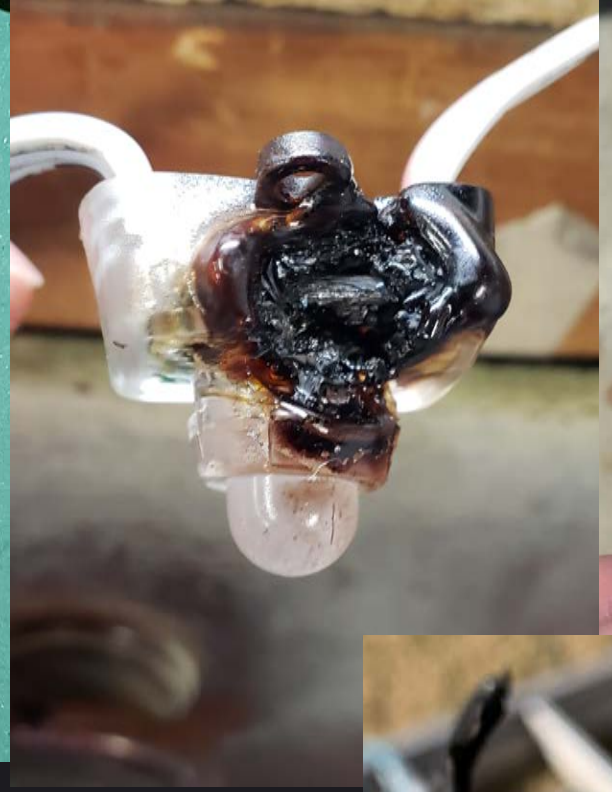

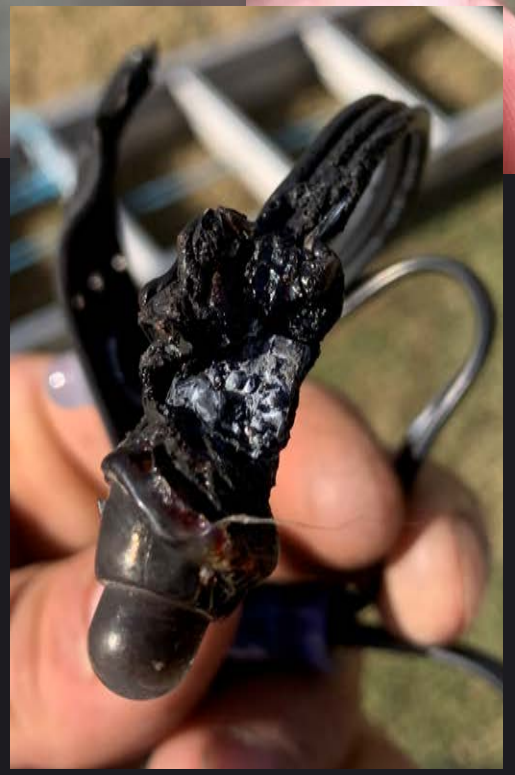

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Myth Busting #1

- Why not collect brightness settings in survey?
  - Fires were reported / captured on film as happening during the day when pixels were off, but still energized.
  - During show conditions, pixels are off more than on, and when they are on, they are usually one or two primary colors, not white.
  - I'd argue most people use 12V with long runs only by going lower in brightness.
  - Any failure analysis that is made with "worse case" (100% white for long duration) conditions is flawed, as these are very rare conditions "in practice". (Also an issue I have with Ray response about power)
  - Even still, a pixel that can't run continuously 100% white is a defective pixel, we shouldn't have to baby it.

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Myth Busting #2

- Does (lack of) power injection contribute to fires?
  - NO
  - Wires are not perfect conductors. They are long resistors.
  - Due to physics / wire impedance and the low voltage (12V/5V) we use, you can't really overload a pixel string with too many pixels.
  - Pixels start to consume less current when string voltage <6V.
  - Any potential weak points in the wire/PCB adds resistance, that causes voltage to drop sooner, that causes less pixels on the string to draw full current.
  - It's a self regulating system in a sense.
  - This effect goes away with higher voltage pixels. 24V/36V etc. Then you have more voltage to cause problems.

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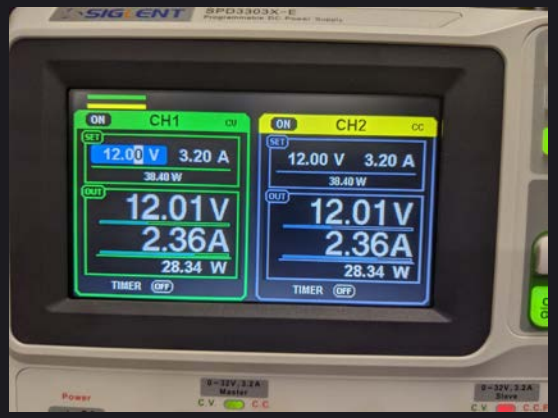
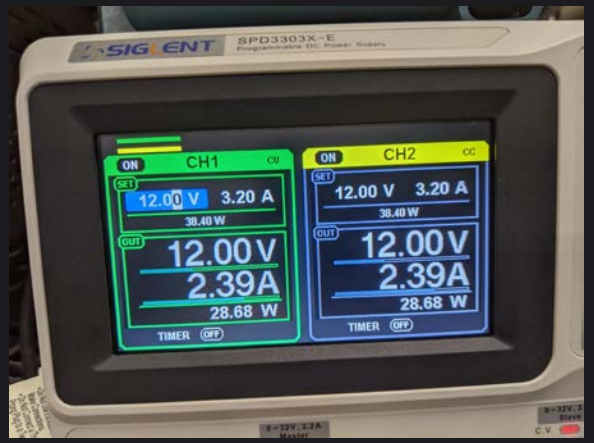
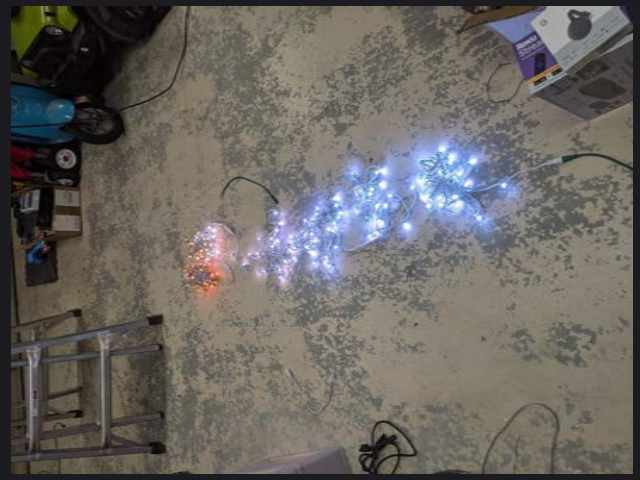
More Pixels Test

- 100 pixels
  - 4.6A



- 200 pixels
  - Should be 8A
  - Instead 4.8A





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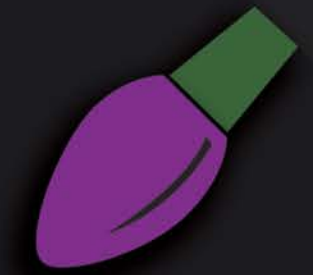
Myth Busting # 3

- Correct fusing should have prevented this, right?
  - NO …(sorry)
  - Like before, wire resistance somewhat “regulates” what can feed into a fault.
  - In order to get one spot hot enough to start a fire, it needs resistance.
  - Dead shorts don’t get very hot themselves, because they are low resistance.
  - So there’s a balance. You need just the right amount of resistance at the right place in the string to get enough energy into a fault to start a fire.
    - Too close to start of string, likely you would blow the fuse.
    - Too far at the end, not enough power can be feed into the fault and you just get charring.
    - Middle is the sweet spot. Not enough current can flow to blow the fuse, but enough to light off a fire.



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Dead Short Test

- After 100 pixels
  - 4.6A

- 200 pixels
  - 2.8A

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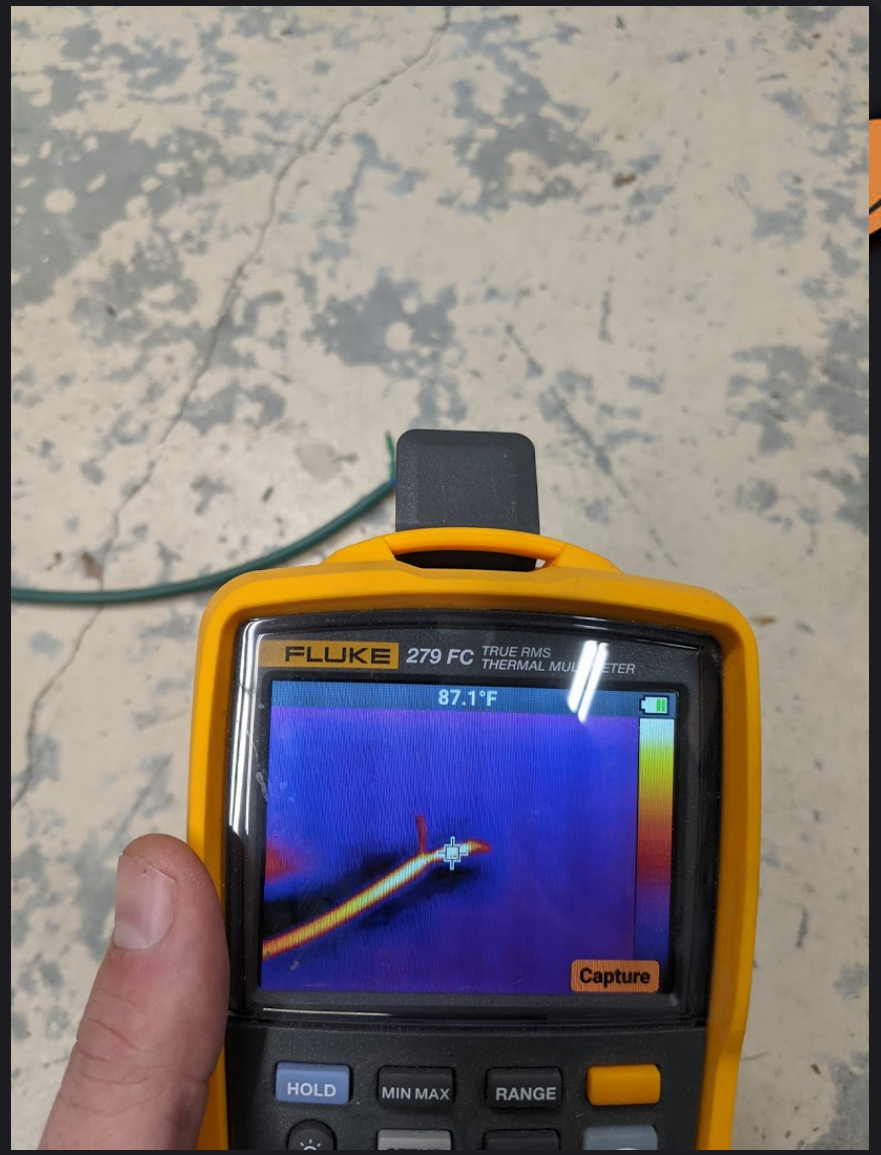

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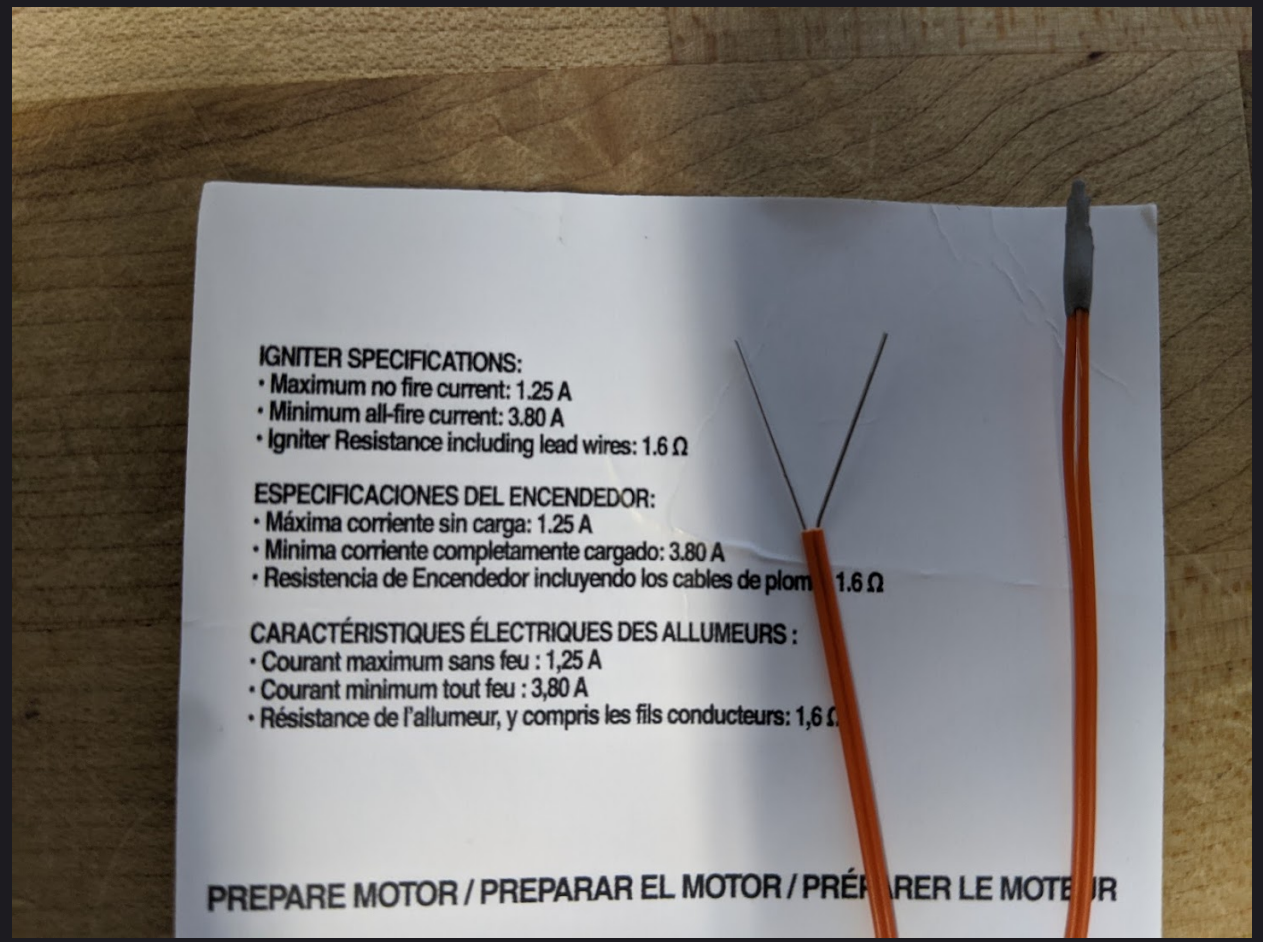
To make fire

- You need the right amount of resistance in the right place.
- Not a short.



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Myth Busting #4

- Are 5V pixels less prone to fire?
  - Yes / Needs Context.
  - The same effect with physics as the last slide, the sooner you lose voltage, the less current you draw.
  - Also Power = Voltage ^{2} / Resistance. The power you can feed into a fault increases exponentially with increased voltage fed into fault.
  - HOWEVER power injection makes this complicated.
  - A fault close to a power injection point could cause a fire. Less wire resistance between power supply and fault means less voltage drop.
  - Correct statement: “5V can still catch fires depending on conditions, however it is less likely.”

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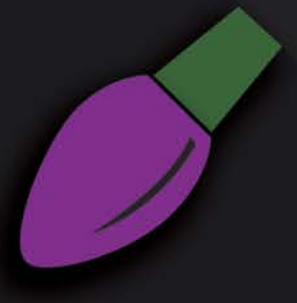
Math Visualized



- Both strings develop a 2 Ohm fault across power lines
- Power = Voltage ^{2} / Resistance
- 12V strings feeds 72 Watts into fault.
- 5V string feeds 12.5 Watts into fault.
- Which gets hotter?

- “5V can still catch fires depending on conditions, however it is less likely.”

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Why were fires different?

- The resistance of the fault defines how much power is fed into it.
- Where on the pixel string the fault happens defines how much power is fed into it.
- Distance from the power supply defines how much power is fed into it.
- And the list goes on.
- So get a spectacular fire, you need the max amount of power you can, plus some oxygen to get the epoxy to catch fire.

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Roadmap to Worse Case

- The “John Spiker” luck factor.

1. Do your pixels have a faulty regulator?
2. If Yes, does that pixel exist in the “sweet spot” along the string?
3. If Yes, does the failing regulator get hot enough to ignite the epoxy?
    - Right amount of resistance in the right place.
4. If Yes, does the epoxy fire get hot enough to ignite the coroplast?
5. If Yes, is your roof flammable?

- I’d argue a large percentage of fire failures stopped at 2 or 3, as evidence by the video and lots of pictures of pixels charred but not bursting / open.

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Fire Failures

- Wrap up
- Survey shows strong evidence of a bad batch of 12V regulated pixels from Ray.
- Ray claims regulators somehow burn more power than resistor, and that he sells the largest quantity to explain the his largest percentage of survey responses.
- Many pixel fires can’t be prevented with proper fusing or testing.
- Adding power injection changes the chances (somewhat) of a full fire vs just a charred pixel, but does not cause or prevent it.
- Luck plays a big part on how bad it gets (if you have defective pixels).

- Next up: Dead Pixels

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Dead Pixels

- Clarify term
- Any pair of pixels that stops passing data is a dead pixel.
- We are never sure if it’s the last working one not sending data, or the first dark one having other issues, but in total there is one dead pixel there.
- Remember we did not count people describing loss of a color but an otherwise working pixel that passes data.

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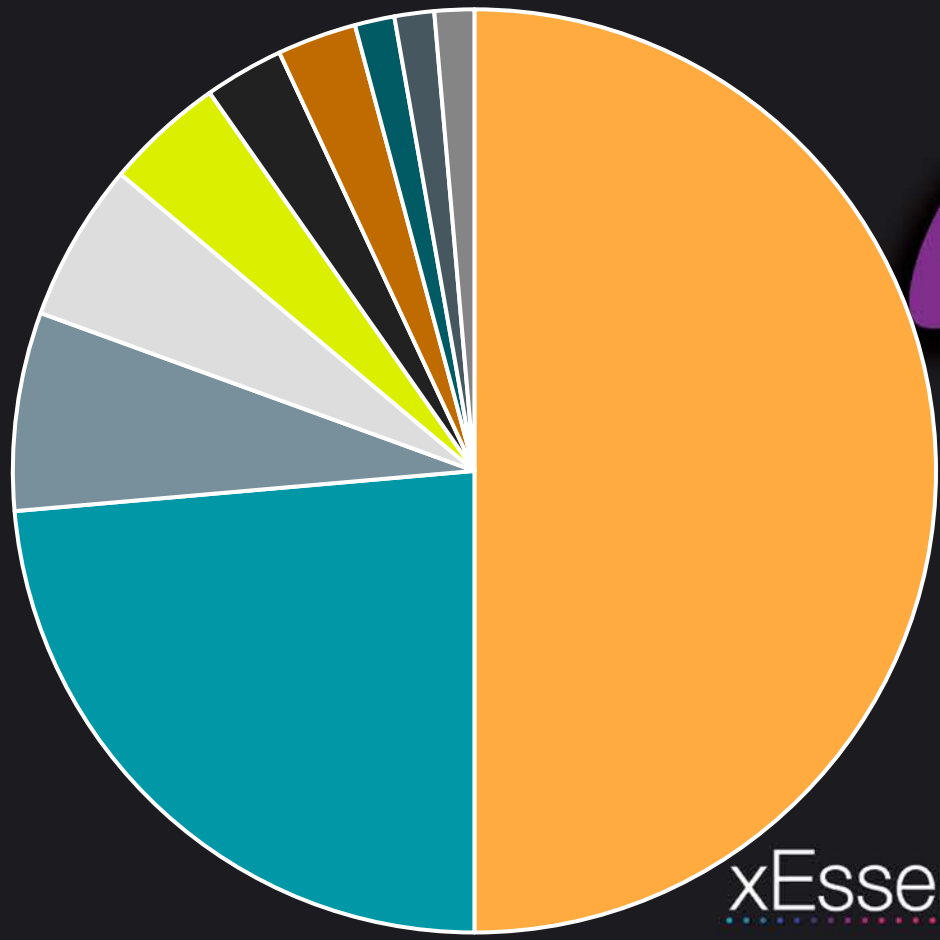
Dead Pixels

- Of dead pixels reported
  - 50% Ray
  - 23% RGBman
  - 7% Paul
  - Remaining 20% split across 7 other vendors, no one vendor over 5%.



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We contacted RGBman

- He confirms he is a reseller of Paul’s pixels.
- If we combine Pauls and RGBman numbers, equals 30% of responses, which is significant.
- Why RGBman is higher than Paul may be due to the Facebook bias. RGBman does lots of business / advertising on Facebook. This survey was also advertised on Facebook.

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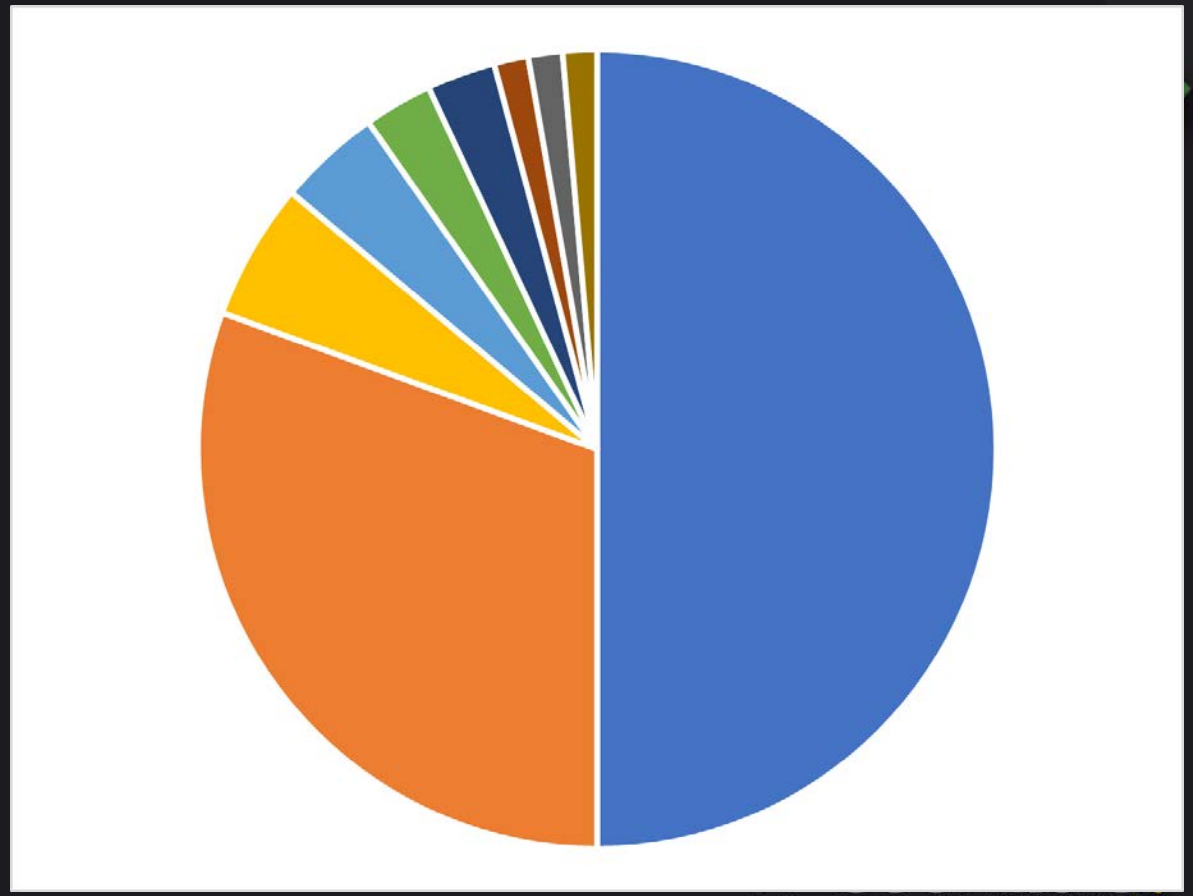
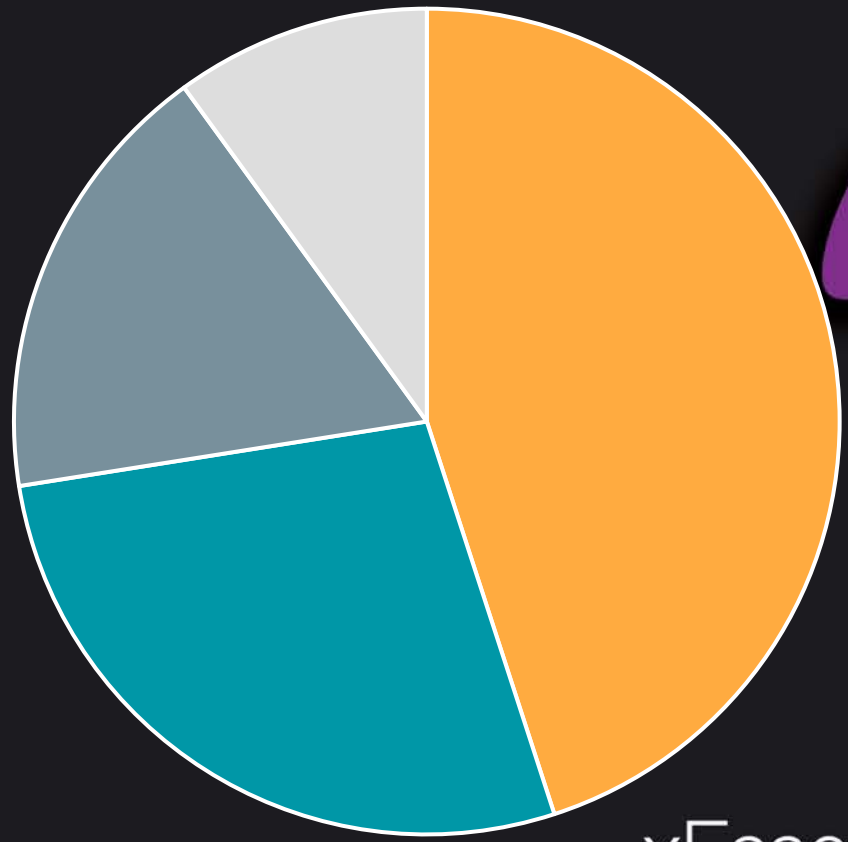
Dead Pixels (revised)

- Of dead pixels reported
  - 50% Ray
  - 30% RGBman + Paul
  - Remaining 20% split across 7 other vendors, no one vendor over 5%.



Dead Pixels

- Of dead pixels reported:
  - 45% 12V resistor
  - 27% 12V regulated
  - 17% 12V unknown
  - 10% 5v
- 79% round, 21% square
- This looks like our best guess at normal community distribution.
- IE, no correlation to voltage, type.



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So what does it mean?

- Something common across the different types and voltages.
- Housing? Epoxy? Soldering?
- When we looked at all the pictures and video submitted, you guys already figured it out:
- Epoxy.
- OR at least there were definitely some issues with epoxy. Can we say that's was the only issue? No.
- A few people showed us what they suspected were bad solder jobs. They could be right, that could be another manufacturing issue. Hard to prove that one.

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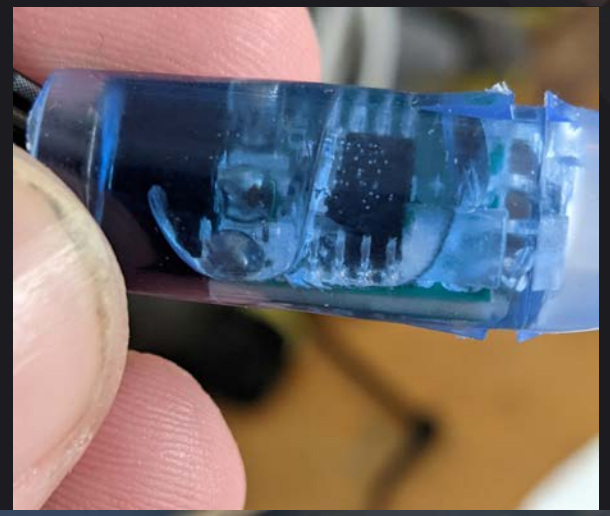
Evidence of Epoxy issues



Vendors of Cracked Pixels

- Only 30% or responses reported they noticed cracked epoxy.
- Of that
  - 69% were Ray Wu
  - 17% were RGBman / Paul

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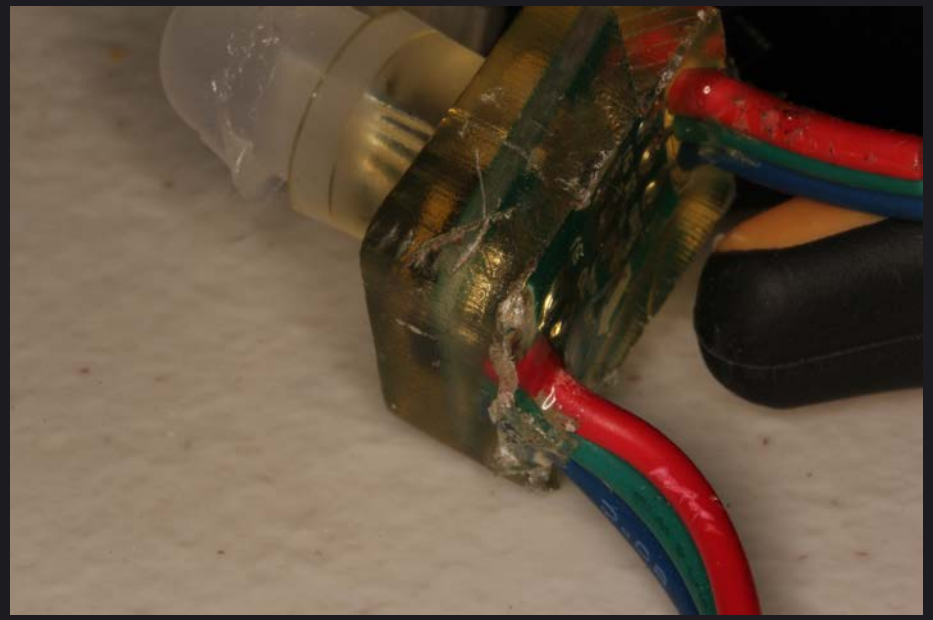
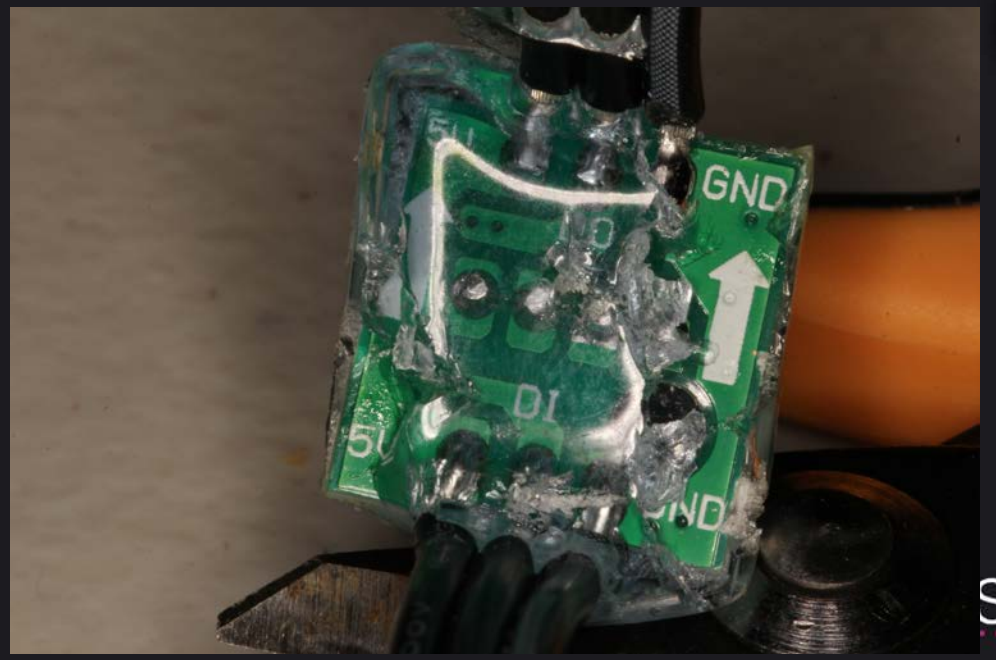
Soft Epoxy

- We also notice a departure for many pixels we had people test, soft epoxy.
- Can be easily ripped into pieces and out of the pixel.
- We are not sure what that means for the failure rates.





Ray’s Response

- “I did have a bad batch of the epoxy resin last year,which caused the pixels cracked after using several months and water came inside. but i think i has only one bad batch of them, actually, i had sent many replacements to customers. I now use another resin supplier,with higher and much stable quality, this issue will not happen again. “

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RGBman's Response

- Once we started getting feedback with customers reporting epoxy issues, Paul shut down his line for a week and fixed the issue. I also believe there were QC issues related to the Covid shutdown. Now that things have settled down, and the epoxy filling machine fixed, things should return to normal.
- Any and all of my customers that had high failure rate should contact me if they feel the issue wasn't resolved.

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Why do we care about epoxy

- Epoxy is what seals the circuit board, wire connections, and components from water.
- Water = bad … for electronics.
  - Great for drinking! (with some hops :P)
- All these failures, if related to the epoxy, means the epoxy failed and let water get in. Cause corrosion and/or disrupt the operation of the pixels.
- You don’t need rain to get water, it’s literally in the air too!

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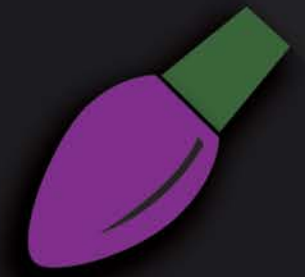
Notes from talking to an epoxy expert

- Picking the right epoxy is hard.
  - Has to bond/seal against different surfaces in the assembly.
- Soft epoxy could be from bad materials used, or incorrect ratio of hardener.
- There are other materials you could use to seal an assembly like a pixel that isn’t epoxy, and would be soft. But they are likely more expensive than epoxy.
- Fire resistant epoxy is much more expensive.
- All epoxy comes from China. And we have to baby sit the factory we use over there.



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Other theories for Dead Pixels

- Soldering issue
  - We did have a minor number of reports with what appears to be soldering issues. People could either see (what looks like) poor solder joints, or they are able to move the pixel and it works again.
  - Some people, when testing the soft epoxy issue, noticed parts (like the control chip) would come off the board and stay stuck to the epoxy.
  - Hard to verify.

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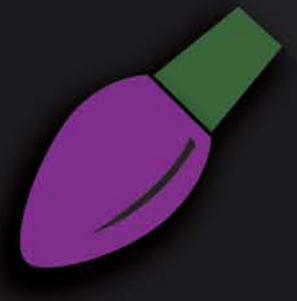
Survey wrap up



- Fires and dead pixels seemed to be unrelated (maybe not, but not my theory)
- I'd argue this year 2020 was an usually high year for failures, but still very small overall amount overall.
- Both vendors we talked too do acknowledge an epoxy issue in some way.
- No direct acknowledgment of fire issue, but a comment on regulated pixels that doesn't make engineering sense.
- Not done yet!

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Myth Busting #5

- “All Pixels come from the same factory, so there’s no reason to buy from a US vendor”
  - FALSE / Needs Context.
  - There are several factories, and even if their weren’t, the same factory can produce different qualities depending on the customers order.
  - AKA, the customer (of the factory) has control over the quality of the product made.
  - When you pick your vendor, you are picking both a person controlling the factory, and the factory, in a sense. They could be the same entity, but most times they aren’t.

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Myth Busting #5

- How do I know this?
  - I talk to my vendors. Do you?

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Myth Busting #5

- Todd (DIYLEDExpress) used to hang out in the forum chat rooms many years ago. He'd tell me stories on how his manufactor would try and sell him on cost reduction options that he'd decline because he felt it was cutting corners.

- Ken (WiredWatts) frequents Expos and other events. He tries to visit the factory he uses annually in person. He also sets rules with them, including aren't allowed to make changes to the materials used in the pixels made for him without his consent.

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Myth Busting #5

- So yeah, all pixels come from China. But who's setting the bar for the quality of the materials used in your pixels?
- Other American (or any country) vendors probably also do the same. You should ask them.
- I'd also argue American vendors should do a better job at selling themselves and explaining this value added.

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Reminder

- The world is “Buyer Beware” by default.
  - The only person ultimately responsible for your purchasing decision is you. Do your own research (off facebook). Ask vendors what value they add. Don’t take my word for it.
  - This isn’t Amazon. You shouldn’t expect good customer return policy and customer support from everyone.

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A plea for better Facebook Discourse

- We shouldn’t have needed to do this.
- I got lots of feedback from people thanking me for doing the survey, because they felt attacked by vendor “fan boys” when they tried to make a post sharing their failure experience. Some deleted their posts because of it. Others were scared to make posts because of it.

- (Maybe) We could have put this picture together without a survey if not for these issues causing people to stay quiet or remove their posts.

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A plea for better Facebook Discourse

- So don’t be the “I’ve used this vendor for years with no problems” guy on posts of people sharing their experience. It takes away from the otherwise meaningful discussion on trying to figure out causes of failures.
- Everyone already knows that vendors 99%+ of the time put out working product. That doesn’t need to be reinforced on every post.
- Without that noise, maybe the trends could have been better spotted without all this work.

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We are Improving

- Boscoyo Studio is switching all coro material to a new product that is more fire resistant.
- One last note from Ray's message. He says he's looking into fire resistant epoxy for this year even if it makes the pixels more costly.
    - It should according to the epoxy expert I talked to.

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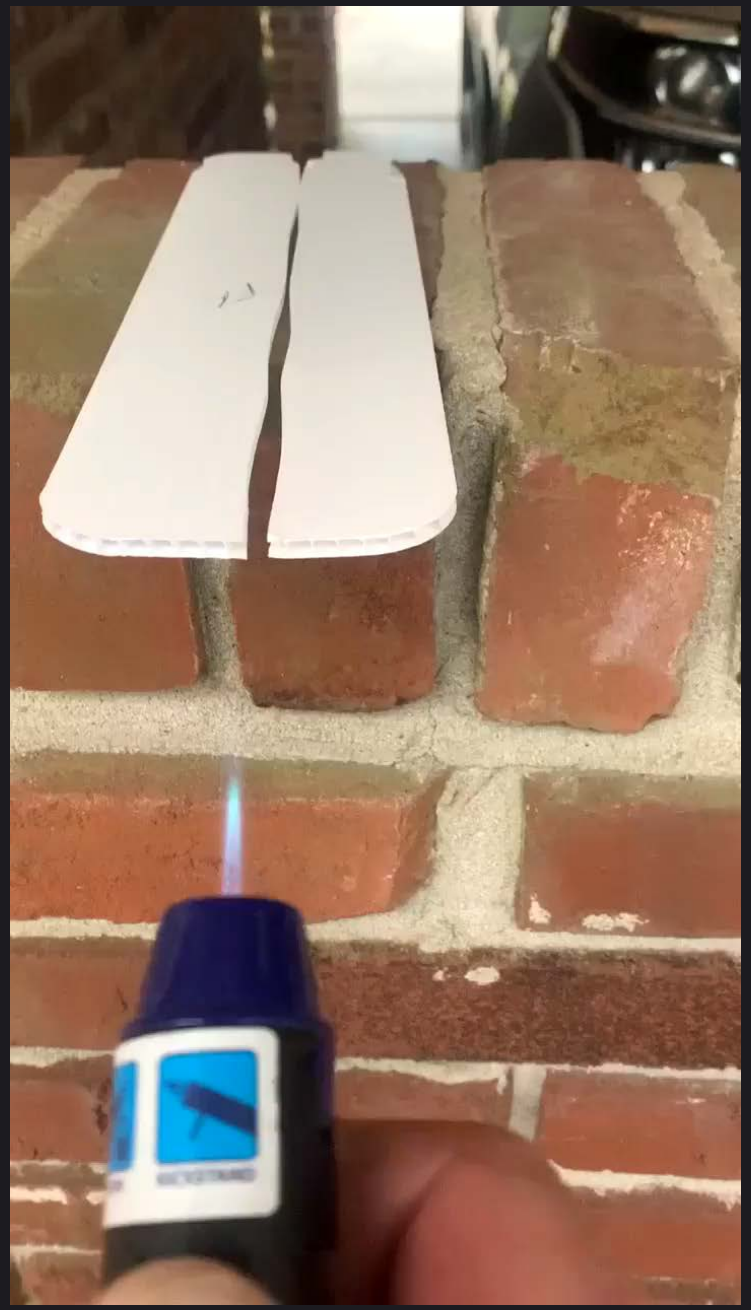

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