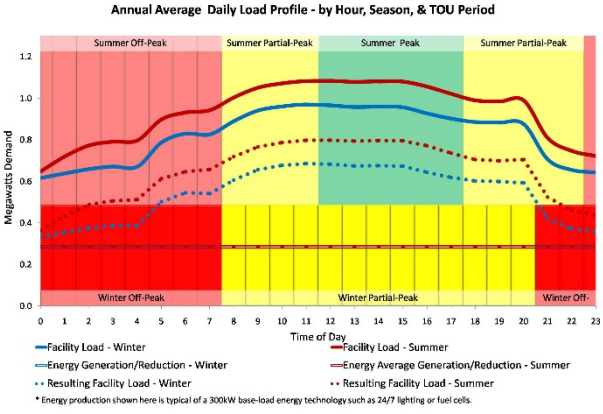
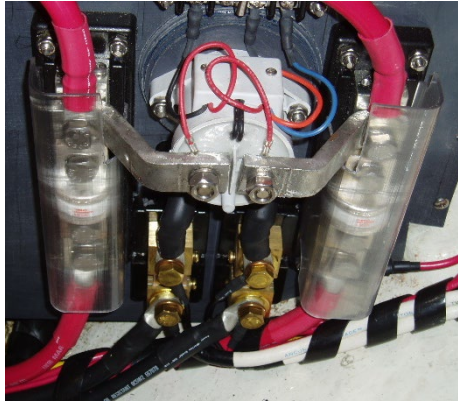
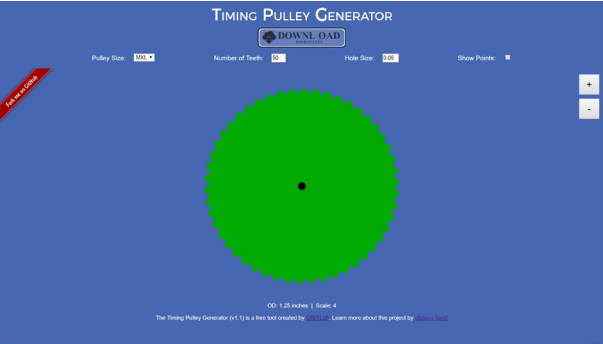


Product Validation, Electrical Design, and NRTL Listing

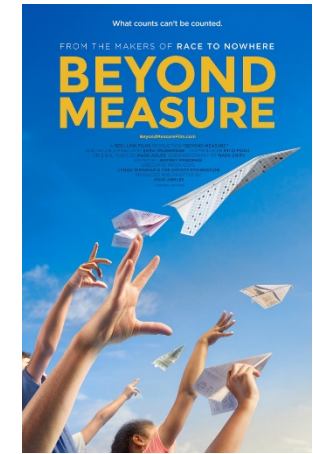
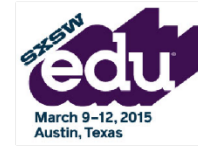


A practical guide to product safety for entrepreneurs and small businesses.

Experience

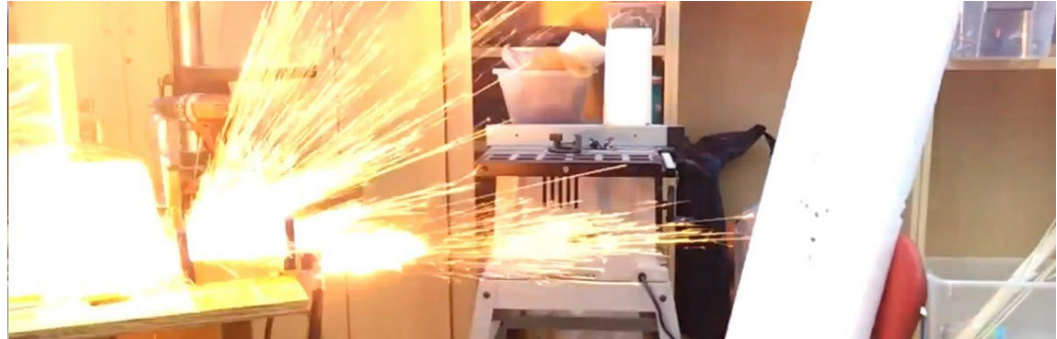


Shop Class

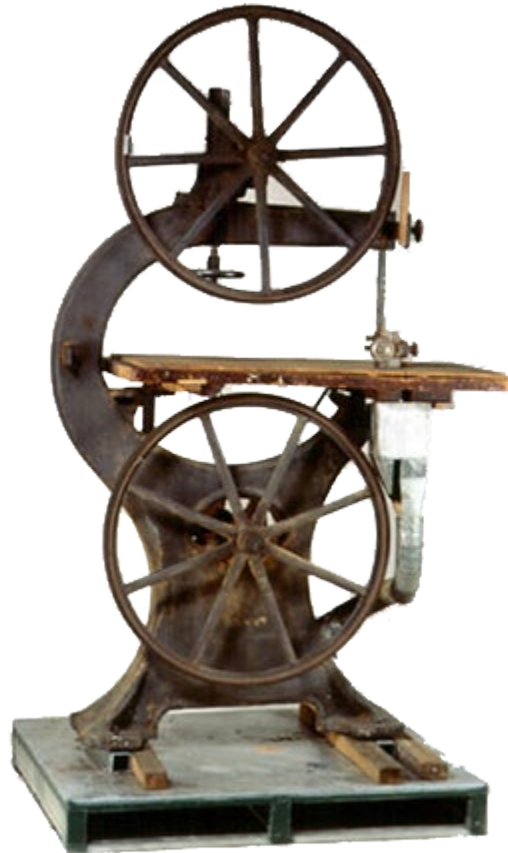


LEMELSON-MIT

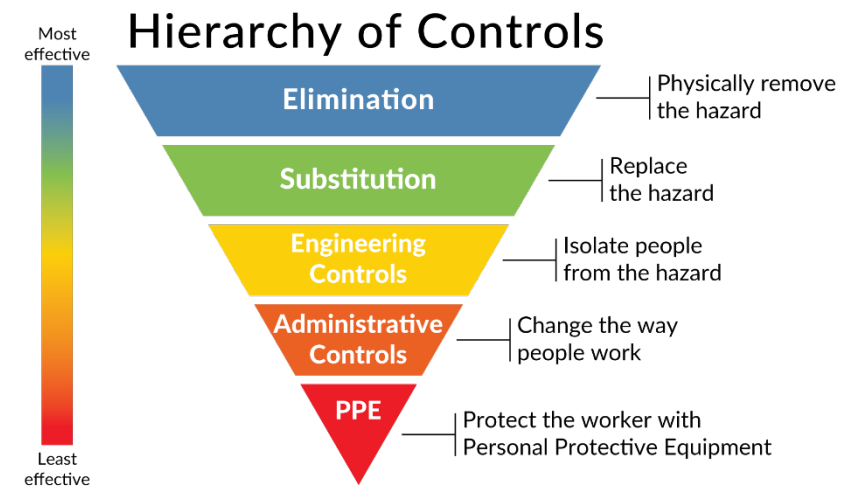
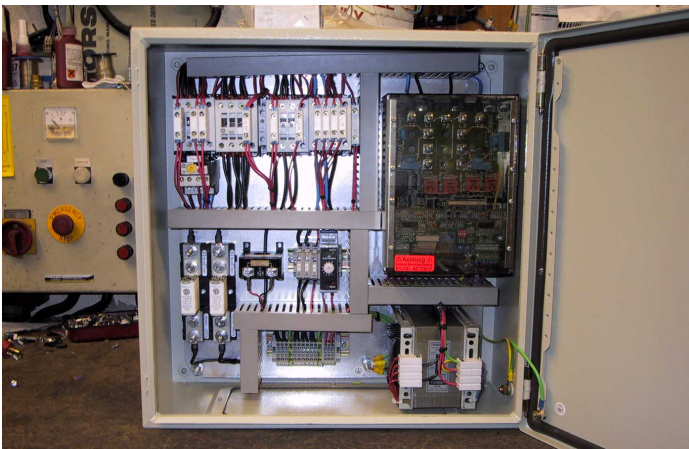
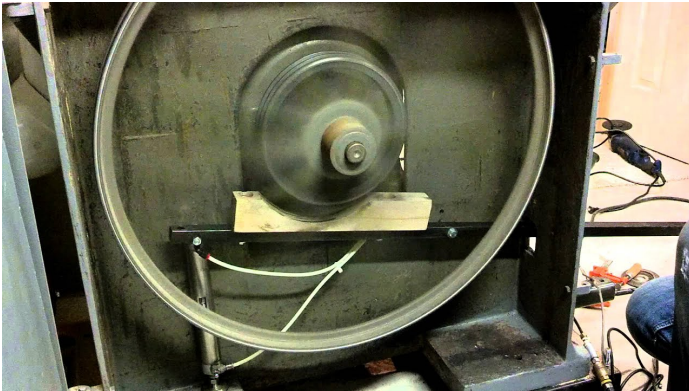
THE PAUL G. ALLEN FAMILY FOUNDATION



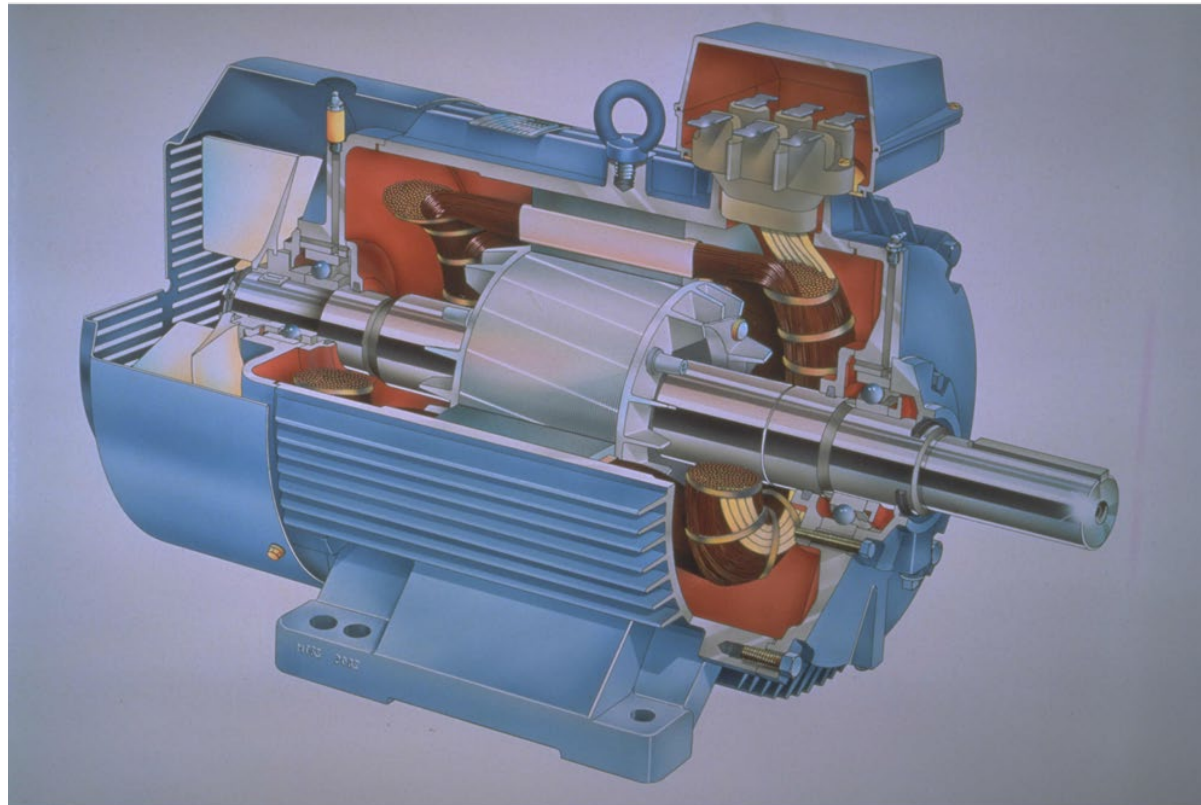
Newton's First Law



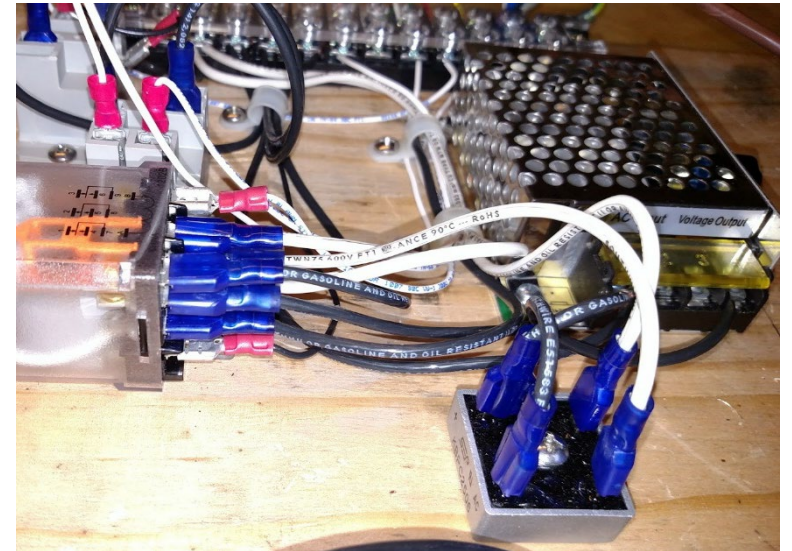
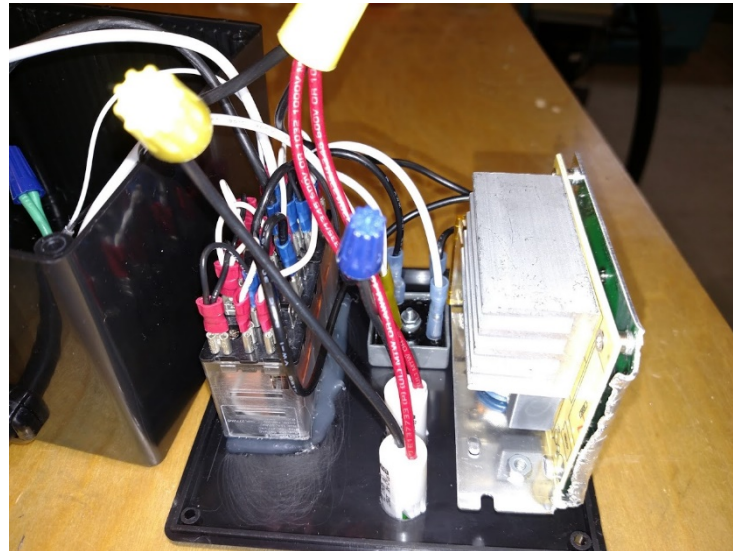
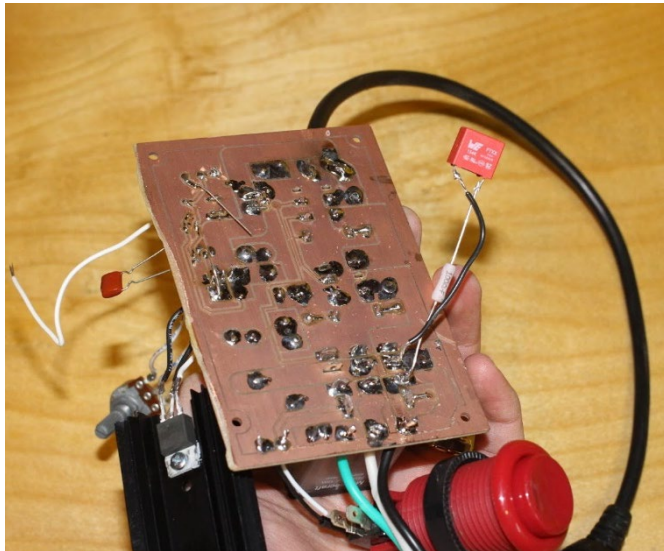
Exploration of Braking



DC Injection



Prototyping

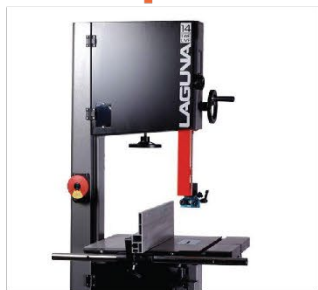


First Steps

I needed a way to quickly stop a bandsaw in my shop.

Nov 2016

A Need



Research

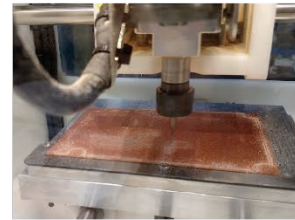
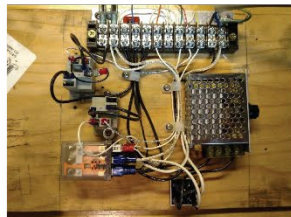
Dec 2016

With a variety of tools that needed braking, a custom and invasive mechanical solution for each didn't make sense. I found DC Injection soon after.

This was my first proof that the concept and was the start of a long development process.

Jan 2017

1st Prototype



Development

Jan - Nov 2017

I spent months designing for manufacturability and reliability and went through approximately four more versions of the device.

I filed my provisional patent.

May 2017

Prov. Patent



Development

Jan - Nov 2017

Development continued as I moved into my first full PCBA board.

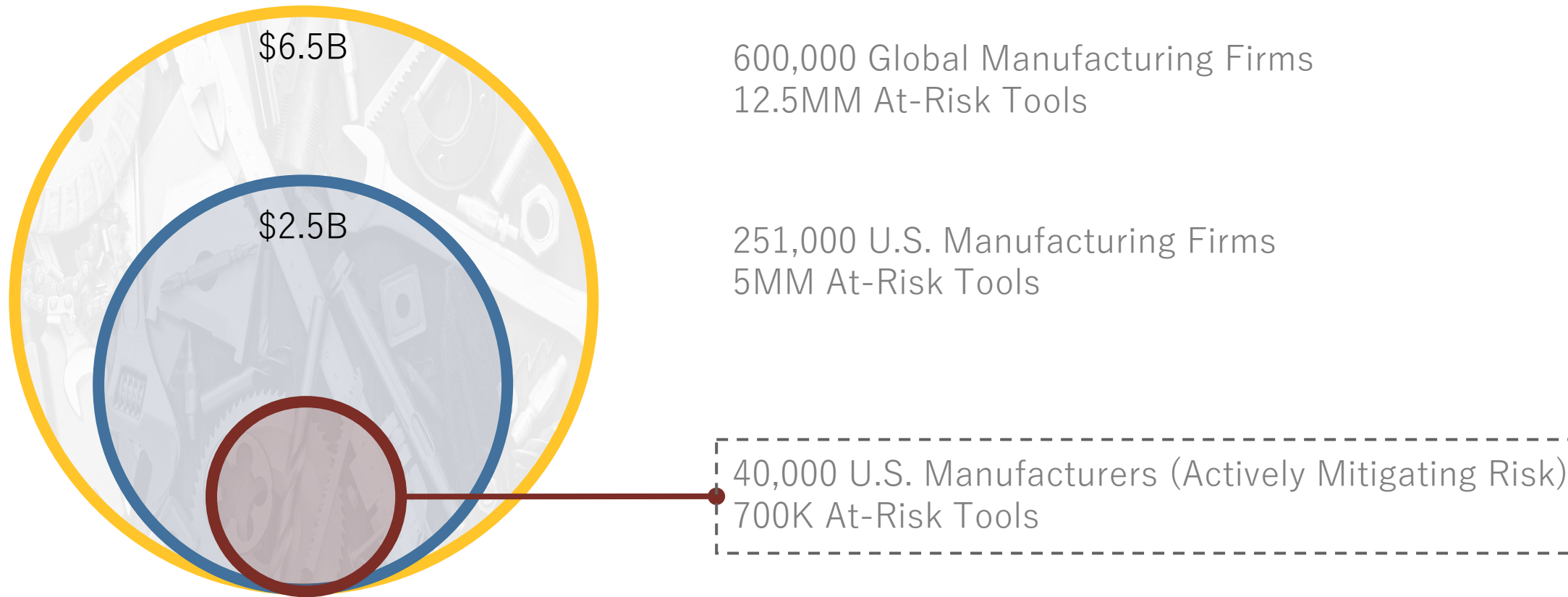
I began to exhibit and share my product at trade shows and received very positive feedback.

Apr & Aug 2017

Showing Off

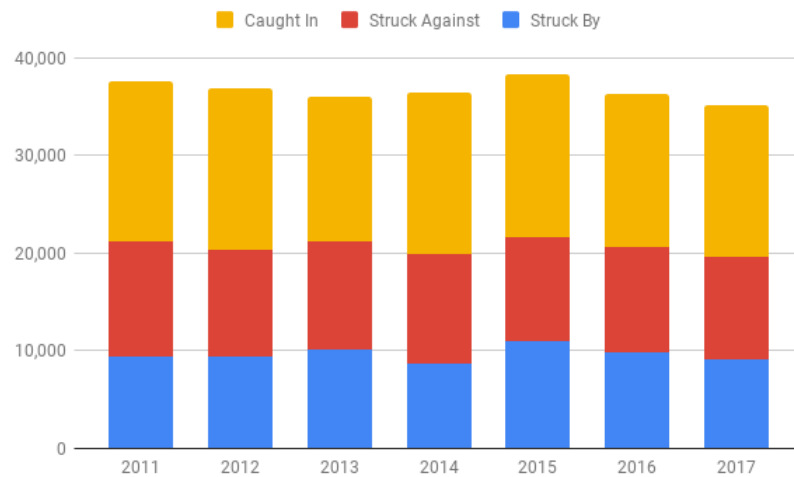


A Business?



Injury Profiles

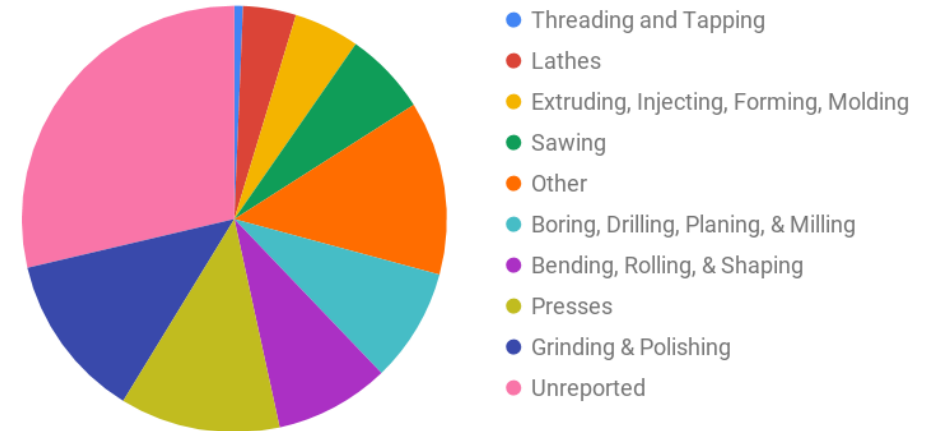
Injuries Over Time



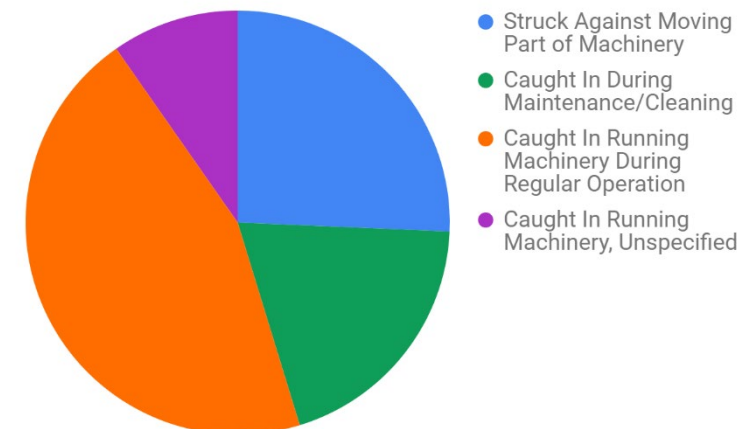
Number of nonfatal occupational injuries and illnesses involving days away from work by [all] workers, All U.S., all ownerships, 2011 – 2017.

SOURCE: Bureau of Labor Statistics, U.S. Department of Labor, Jul 6, 2019

Injuries by Machine



Injuries by Operation



Recurring Hazards

- The Control of Hazardous Energy (Lockout Tagout)
- Accidental Restart
- Coasting
- Emergency Situations & E-Stop
- And more ...



Bench
Grinders



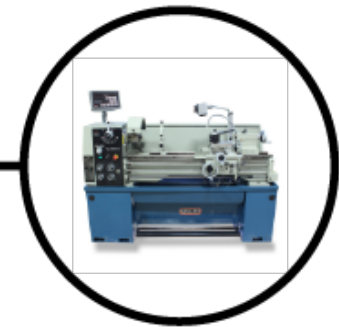
Table
Saws



Band
Saws



Disc
Sanders

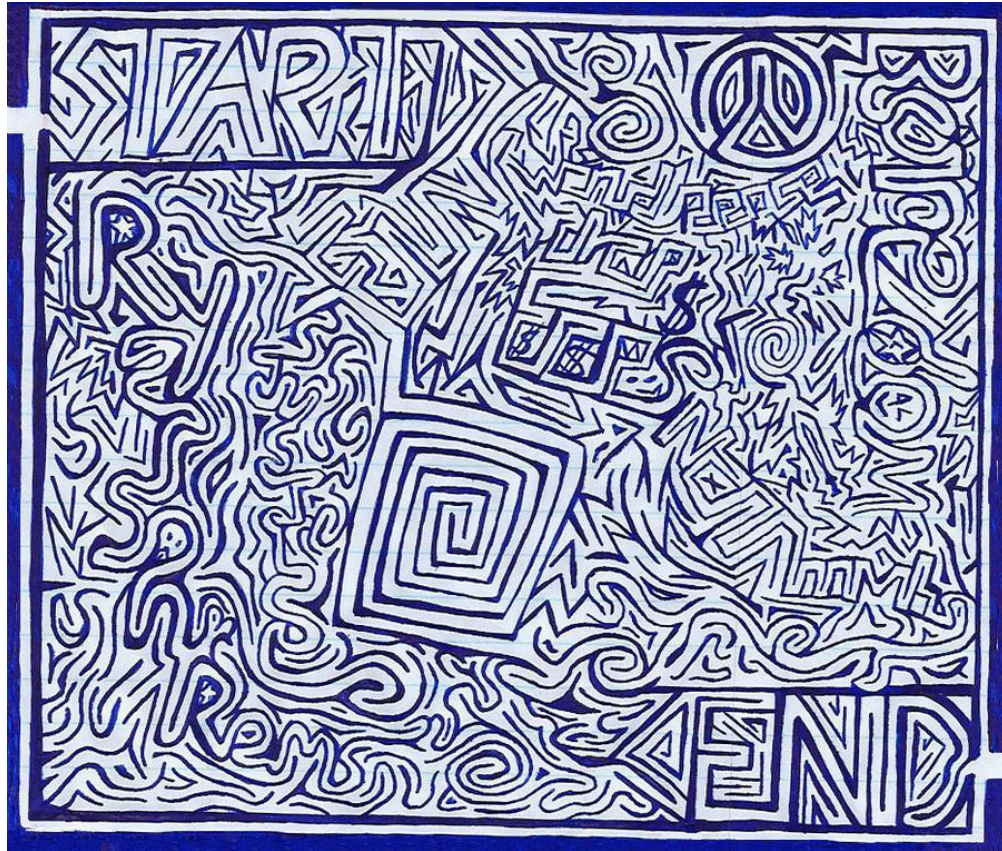


Lathes

Disclaimer

- This was a learning process.
- I'm sharing what I tried and what I did ... that doesn't mean it's what you should do.
- Use your head when trying things on your own or building your own test equipment.
- Don't give-in to imposter syndrome.
- Learn a ton about your product!

What's a Nurtle?



NRTL Struggles:

- Identifying the relevant standard(s)
- Paying for standards!?
- Being stuck *in-between*
- Customer disservice
- Requirements vs. best practices
- Misleading listings and the longest path to nowhere.

**CAL/OSHA Petition
580**

Recorded Webinar:
[youtu.be/b5DhKy9-
ao](https://youtu.be/b5DhKy9-ao)

OSHA








Fed/OSHA is the
regulating body that
oversees and
regulates NRTLs.

Standards and Tests

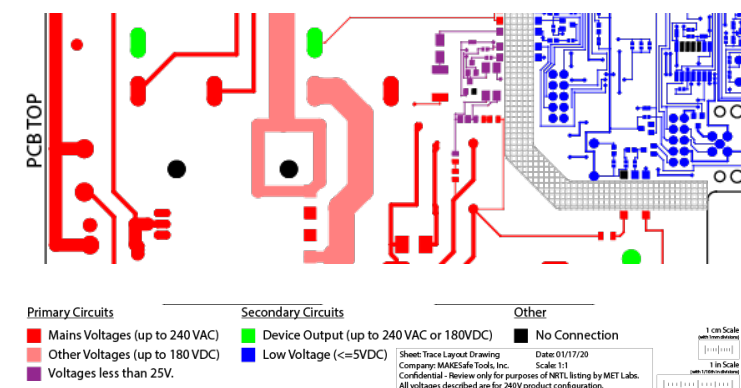
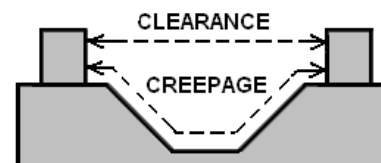
- UL508 vs UL508A – Industrial Motor Controls
- Primary Tests: Temperature/Endurance, Short Circuit, Dielectric
- Other Tests: Push Back, Strain Relief, Marking Durability, Leakage Current, Spacing
- Product definition vs. existing products & existing standards

Clearance & Creepage

Clearance/Creepage

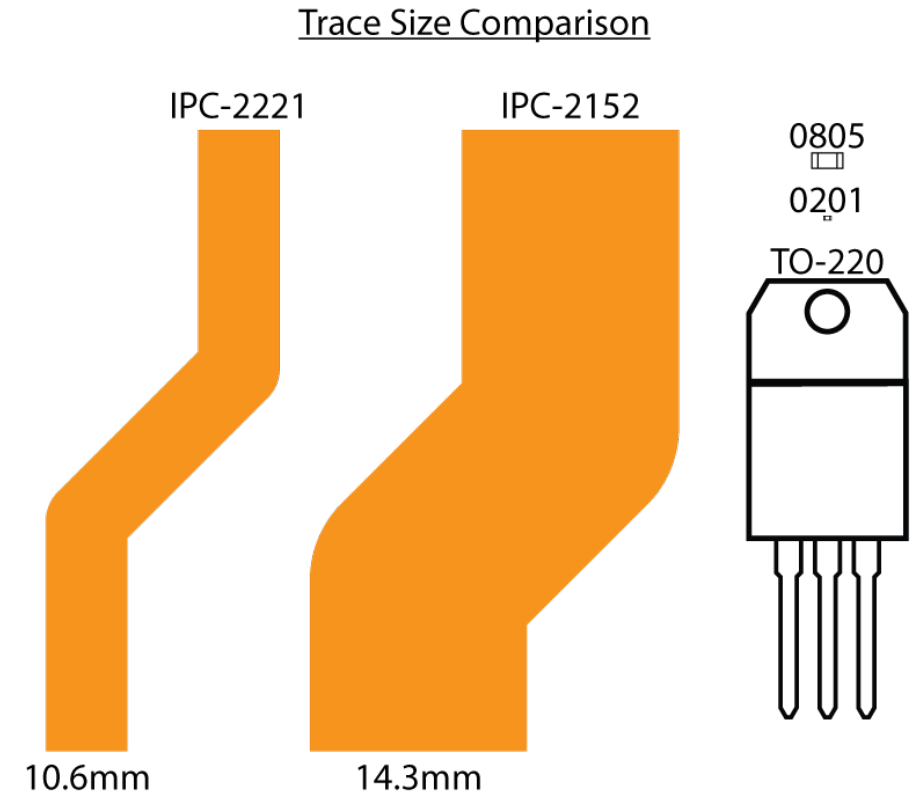
1.0/2.5		UL840 §9
1.6/3.2		UL508 §37.8
2.3/2.3		UL508 §37.6
2.4/2.4		UL508 §37.6
3.0/-		UL840 §8
3.2/6.4		UL508 §37.1
3.8/5.0		UL508 §37.3

- UL508 vs. UL840
- Buying another standard
- Pollution Degree, Overvoltage Category, and PCB Type, CTI, etc.
- Secondary / SEL Area



Trace Width

- Voltage drop, temperature rise, routing, and real estate
- IPC-2221B vs. IPC-2152
- Diminishing returns for trace width.
- Planes, internal/external, etc.
- For example (20 amps, 3" of 2oz copper, 25°C temp rise):
 - IPC2221: 211 mils (most calculators & tables)
 - IPC-2152: 560 mils (my application)
- Saturn PCB Toolkit
- UltraCad Calculators
- <https://www.smps.us/pcb-calculator.html>



Temperature & Endurance Testing

How to power it?

- Needed:
 - 3Ø 240V supply, 7kW capacity, 100% duty cycle
- Available:
 - A single 120V residential receptacle
- Solution:
 - Install 240V sub-panel in lab with independent feeder from main service panel.
 - Install and balance rotary phase converter.
 - Install delta-wye variacs to balance phases by hand.

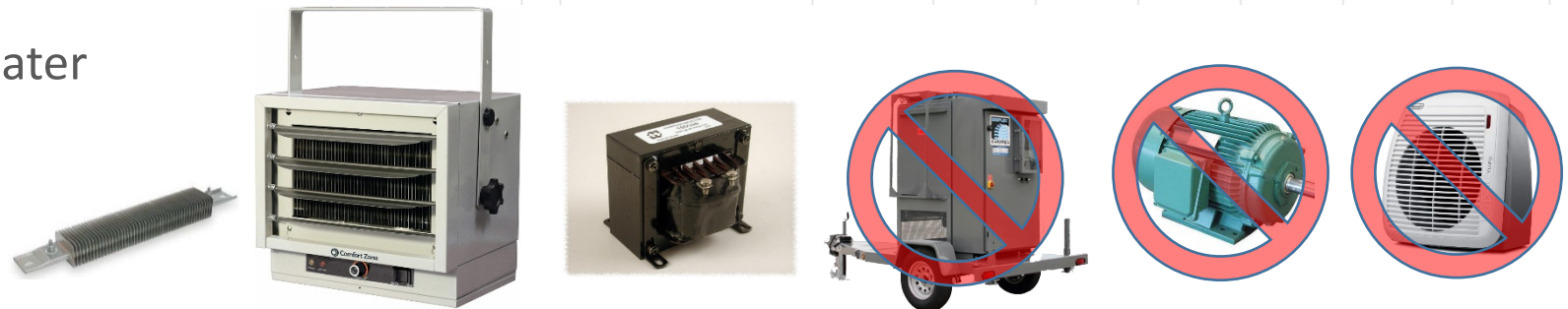


Temperature & Endurance Testing

How to load it?

- Needed:
 - 3Ø 240V loads, AC/DC tolerant, 7kW capacity, 100% duty cycle
- Available:
 - <\$500
- Solution:
 - Calculations & Google-fu
 - Surplus inductors
 - Modified industrial heater
 - Misc. controls
 - A window

Inputs	Frequency	60						
	Power Factor	0.60						
	Voltage	240	Indiv. Part Value For					
	Current (Amps)	8.8	Two in Series	Two in Parallel	Three in Series	Three in Parallel	Four in Series	Four in Parallel
Outputs	Apparent Power (VA)	2,112						
	True Power (W)	1,267	634	634	422	422	158	158
	Z (Ohms)	27.27						
	Resistance (Ohms)	16.36	8.2	32.7	5.5	49.1	8.2	130.9
	Reactance (X)	21.82						
	Inductance (mH)	57.9						
			211	211	141	141	53	53
Purchasing Guide	Voltage Across R	144	72	144	48	144	36	144
	Listed "Power Rating" of R @120V, for impedance selection.	880	1,760	440	2,640	293	1,760	110
	Listed "Power Rating" of R @240V, for impedance selection.	3,520	7,040	1,760	10,560	1,173	7,040	440



Temperature & Endurance Testing



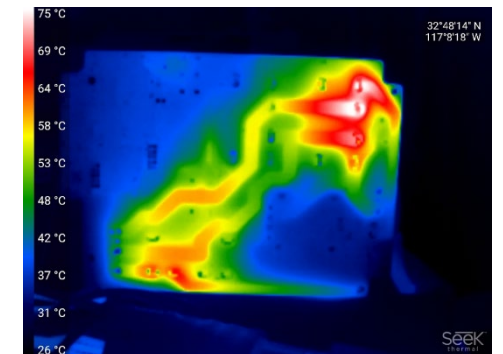
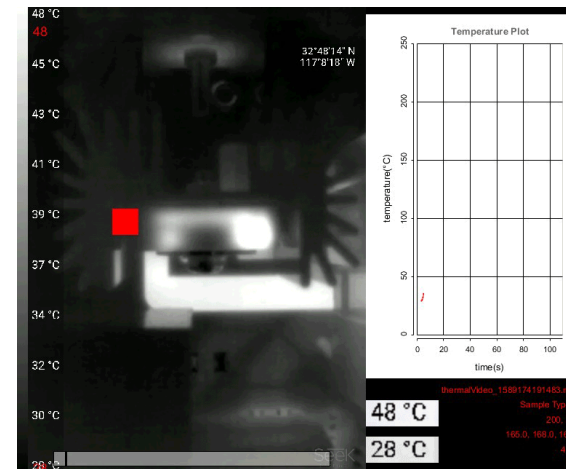
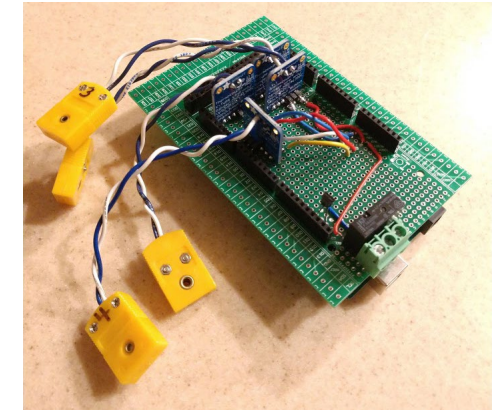
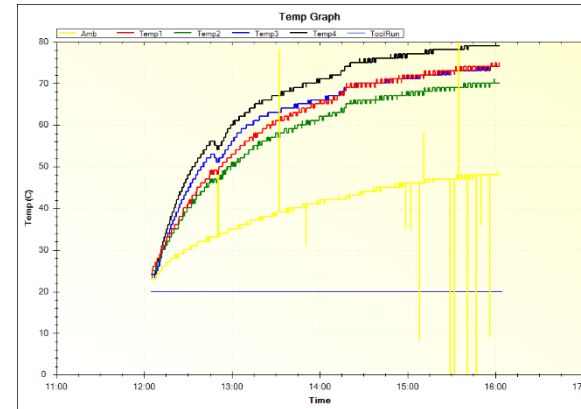
- [Specifying Loads](#) for Shopping
- PTC Heaters
- Fin Heaters
- Enclosures & Operator Safety



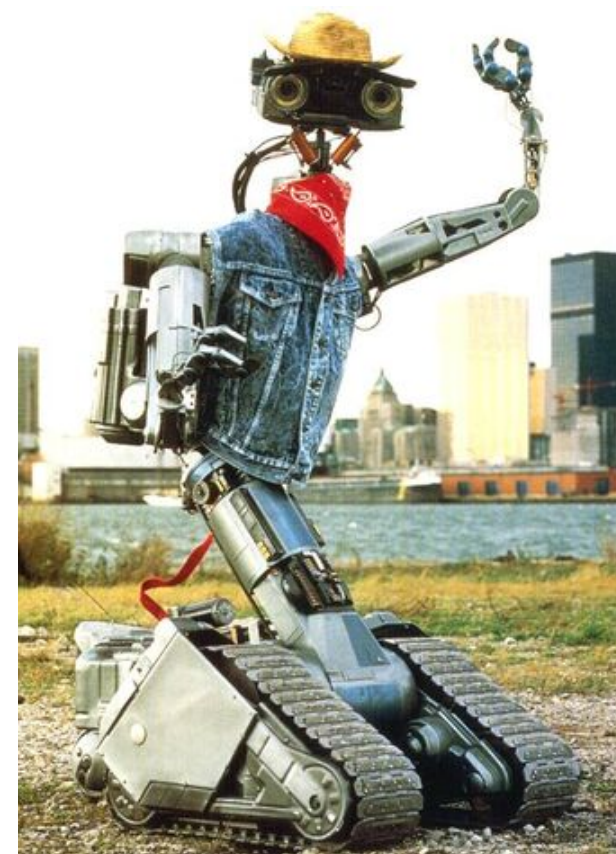
Temperature & Endurance Testing

How to measure it?

- Needed:
 - 5+ test points (temperature)
 - 2+ test points (V/I)
 - Logging & visualization
 - A heated test chamber
- Available:
 - An Arduino
 - A pile of thermocouples
 - A cheap thermal camera
 - A small room and a big load



Short Circuit



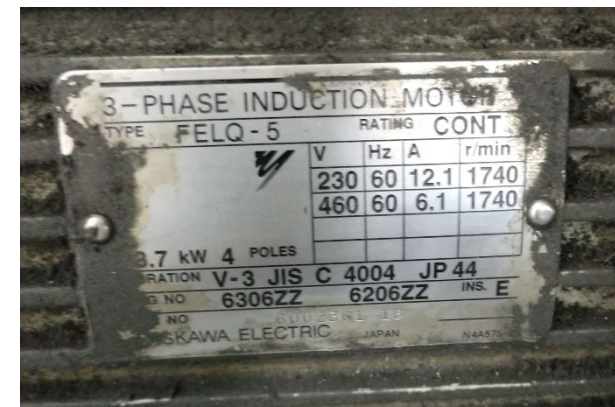
Dielectric

- Listed spacings.
- NRTL listed parts.
- plastic enclosure + SEL isolation.
- electrophoresis power supply and isolated current measurement.



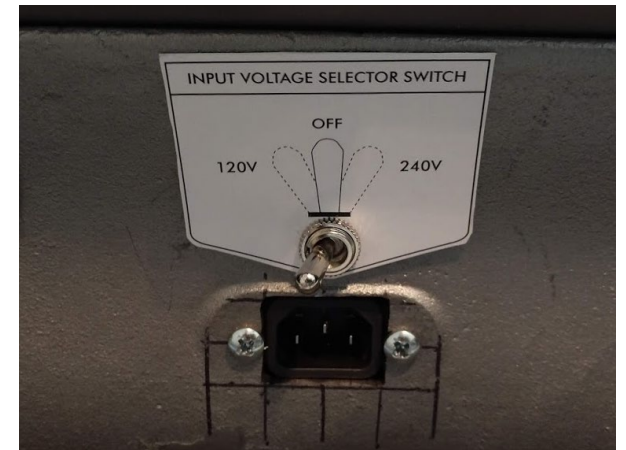
Labels. Ugh.

- UL 94
- Marking Durability
- Cost & Volume
- Alcohol Swab



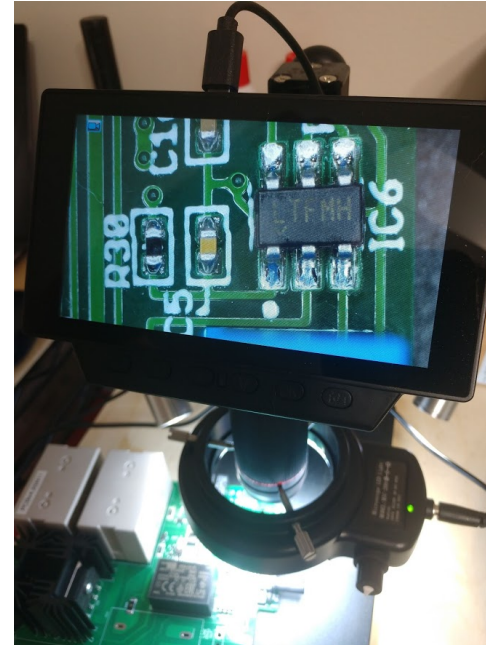
Test Considerations

- Cost
- Shipping
- Usability
- Durability
- Test operator safety
- **Documentation**
- Software



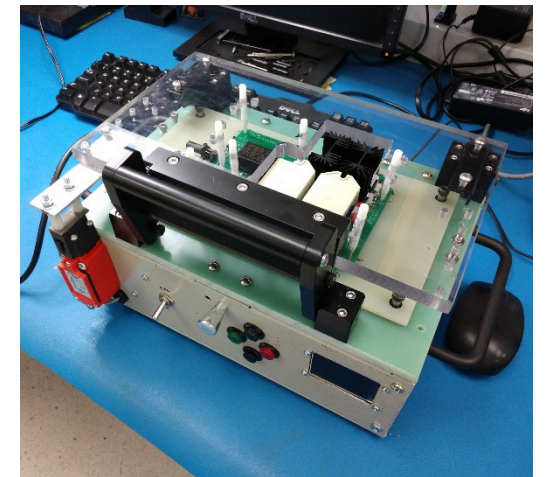
Design Considerations

- Manufacturability
 - PCB cleaning
 - Solder-waveability
 - Dielectric testing
 - Inspections
 - Tooling & indexing
 - Torque standards



Production-Line Testing

- Function PCB Testing
 - Operator Safety
 - Test Reliability
 - Data Logging



Bandsaw Demo



Thanks & Questions!?

- Visit us at www.makesafetools.com
- Learn more about CAL/OSHA petition 580: <https://www.makesafetools.com/unexpected-startups-how-osha-petition-580-seeks-to-protect-workers/>
- Contact me:
 - scott@makesafetools.com
 - (415) 937-1808

