Wire you shocked?

Electrical safety in the Brewery

Protect equipment? Or people?

Russell A. McCrimmon, O.H.S.T.
This presentation is dedicated to
Content

• Begin with the basics of injury and damage
• How we prevent injury
• How we prevent damage
• Equipment selection
• Safety by design

• The most basic concepts
• to more advanced knowledge

To protect equipment?
Or to protect people?
OSHA to BA Safety member:

OSHA can lock your doors, just as quickly as TTB
Cost of injuries
Business costs?

- Lost time, production
- Lost equipment
- Lost product
- Lost worker
To the Person?

- Medical treatment
- Lost wages
- Mental Therapy
- Physical Therapy
- Lost career
- Affect on Family?
Estimated Average cost

• Employer’s direct costs depend on workers' comp “co-pay”.
• Employer always pays the indirect costs.
• Additional sales based on 20% profit margin
• “I’ll use my personal insurance coverage”??

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Direct Cost</th>
<th>Indirect Cost</th>
<th>Total Cost</th>
<th>Additional Sale (Indirect)</th>
<th>Additional Sale (Total)</th>
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</thead>
<tbody>
<tr>
<td>Electric Shock</td>
<td>$93,858</td>
<td>$103,243</td>
<td>$197,101</td>
<td>$516,219</td>
<td>$985,504</td>
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<td>Burn</td>
<td>$40,188</td>
<td>$44,206</td>
<td>$84,394</td>
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fundamentals
• I = E/r
• I = current, is the flowing electricity
• E = volts, force that pushes
• r = resistance trying to hold it back

• W = watts of power
• combination of volts and current gives watts
• 745.7 W = 1 Hp
Look at your pump motor:
higher voltage, uses lower amperage
Does a SHOCK damage human cells?
When do I feel a shock?

- When am I in danger?
- Low level electricity causes injury
- Maximum safe voltage only 10V
- Physical affects from milli-amps.

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<th>FEELING OR LETHAL INCIDENCE</th>
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<tbody>
<tr>
<td>60HZ</td>
<td></td>
<td></td>
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<tr>
<td>&lt; 1mA</td>
<td>None</td>
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</tr>
<tr>
<td>1mA</td>
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<td></td>
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<td>2-10mA</td>
<td>Sensation of shock</td>
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<tr>
<td>5mA</td>
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<td>Ground Fault Circuit Interrupter Operates</td>
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</tr>
<tr>
<td>&gt;200mA</td>
<td>Tissue Burning</td>
<td></td>
</tr>
</tbody>
</table>
Electrical safety

- Amps are from Voltage and Resistance
- Body resistance can be 500 ohms.
- 1000 ohms is realistic for wet, intact skin.
- Broken skin has less resistance
- Voltage breaks down skin cells.
- Lowers resistance.
• Current causes injury, not voltage.
• Current passing through depends on resistance.
• Resistance of the body can be as low as 500 ohms.
• 60 volts through 500 ohms is 120 milliamperes; enough for serious injury.
• Documented serious injuries are proof that below 50V is dangerous.
• Auto mechanics: 12-volt at 24 milli-amps.
Power of electricity
Hire an industrial or commercial electrician

• “Switch” doesn’t kill power in circuit
• Shut off power at breaker
• **1** electrocution per day
• **6** electrical burns per day
• **2 of 3** are worker error
• Arc Flash is not “shock”

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### By The Numbers

<table>
<thead>
<tr>
<th>How Often</th>
<th>Number</th>
<th>Effect</th>
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<tbody>
<tr>
<td>United States Annual</td>
<td>4,000</td>
<td>Non-Disabling electrical contact injuries</td>
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<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States Annual</td>
<td>3,600</td>
<td>Disabling electrical contact injuries</td>
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<tr>
<td>Average</td>
<td></td>
<td></td>
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<tr>
<td>Every Day</td>
<td>1</td>
<td>Person is electrocuted in the workplace</td>
</tr>
<tr>
<td>Electrocutions are</td>
<td>4th</td>
<td>Leading cause of traumatic occupational fatalities</td>
</tr>
<tr>
<td>Each year</td>
<td>+2,000</td>
<td>Workers are sent to burn centers with electrical burns</td>
</tr>
</tbody>
</table>
NFPA 70e HOST AND CONTRACT EMPLOYERS' RESPONSIBILITIES

• **110.3(A)** Host employer *communicates hazards to contractor*
  • Include info the contractor needs to assess safety
• **110.3(B)** Contractor trains employees on electrical safety
  • Communicates *hazards identified by the host*
  • Contractor must report to host, any new hazards
• **110.3(C)** “…shall be documented meeting between host and contractor.”
NFPA 70e HOST AND CONTRACT EMPLOYERS' RESPONSIBILITIES

- Electrical schematic drawings
- Questionable, faulty circuits
- Circuit Voltage and amperage
- Proper labels that Identify

**WARNING**

Arc Flash and Shock Hazard
Appropriate PPE Required

<table>
<thead>
<tr>
<th>89 inch</th>
<th>Flash Hazard Boundary</th>
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<tr>
<td>16.4 cal/cm²</td>
<td>Flash Hazard at 18 Inches</td>
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<tr>
<td>Class 3</td>
<td>Cotton Underwear + FR Shirt &amp; Pant + FR Coverall</td>
</tr>
<tr>
<td>480 VAC</td>
<td>Shock Hazard when cover is removed</td>
</tr>
<tr>
<td>00 Glove Class</td>
<td></td>
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<tr>
<td>42 inch</td>
<td>Limited Approach (Fixed Circuit)</td>
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<tr>
<td>12 inch</td>
<td>Restricted Approach</td>
</tr>
<tr>
<td>1 inch</td>
<td>Prohibited Approach</td>
</tr>
</tbody>
</table>

Bus: C-H Prot: MCB C-H
That means

I AM RESPONSIBLE

for my electrician

going home in one piece
Electrical safety NFPA 70e Rev 2015

- Do you see the problem here?
- Only a **properly protected** electrician should touch this
- This will **kill**
- By arc
- Or by direct shock
Shock and Arc magnified by water and dust

- Helps electricity travel across easier
- Minerals and dust in water are more conductive
- Dust in air or on exposed circuits
- More impure, more conductive
Prevention vs. protection
Codes, Regulations, Basic good electrical practice

- National Electrical Code
- NFPA
- ANSI
- ASTM
- Factory Mutual
- CE
- Underwriter’s Laboratory
- Am Society of Safety Engineers
- OSHA Subpart S Electrical
- NFPA 70
- NFPA 70e
- UL listings
Electrical 1910.303 to 1910.399

- No openings in boxes or covers
- Use it as it’s engineered
- Rated for necessary amps
- Switches vs. Disconnects
- Equipment access in emergency
- No cords through doors, openings, walls, etc.
Keep access clear for emergency shut off

**CAUTION**

Area in front of this electrical panel must be kept clear for 36 inches. OSHA-NEC regulations.
1910.307 Hazardous locations

- Electrical equipment in dust environments
- Includes lights, motors, cords...
- Includes exit signs, emergency lights, etc.
Fast Fact:
Dust build-up on equipment causes it to OVERHEAT, and can ignite the surrounding atmosphere. Class II equipment must resist this “dust blanket”.
• Correct equipment for the job
• Ground all cords and equipment
• Cords almost as good as new
• Inspect it, if it can be damaged
• Water will puddle in these strain reliefs
Current and cords
Selecting extension cords

- Protective jacket over insulated conductors
- The gray cord design shown is illegal
- Read instructions for proper use and power capacity.
- Select cords rated for your current
- Thick, round, big gauge, high amp cords
Longer cord lower amp capacity
**W**: Suitable for outdoors (wet)

Read cord’s jacket:
- **S**: general use
- **W**: suitable for outdoors
- **J**: 300 V insulation; without a J is 600 V
- **P**: parallel wiring, used indoors
- **O**: oil-resistant cord
- **T**: vinyl thermoplastic jacket
- **E**: thermoplastic elastomer rubber jacket

**•SJTW**
Tips To Remember

• Never use extension cords.
• Extension cords are fire and safety risks.
• Use Outdoor-Rated, Wet location Cords
• Wet cords are moisture-resistant.
• Larger gauge wires for larger equipment.
• Indoor cords are for living rooms.
Stop using a warm or hot cord

- Don’t connect multiple cords.
- Never tape, staple, nail up cords.
- Don't bend or coil cords in use.
- Keep cords out from under feet.

- These magnify heat gain.
- Heat damages materials.
- Increase damage, increase danger.
Cord plug safety

- Outlet and cover plate get hot
- Plug ends get hot at outlet box
- Both plugs get hot
- Entire cord gets hotter
Hot cords

- Current heats cords
- Inductive coupling magnifies heat
Caring for extension cords

• Unplug unused cords.
• Pull on the plug — not the cord.
• Cords are temporary; add more outlets
• Avoid touching equipment or breakers when wet
Caring for extension cords

• Unplug from outlet first, then tool
• Power arcs across the connection
Relocatable power tap

Overloaded electric outlet strip

- Not designed for excess amp draw
- Cannot be permanently mounted
- Must disconnect daily
Grounding versus GFCI
Grounds are path of least resistance

- Dissipate voltage and current if malfunctions
- Test for resistance less than 25 ohms
- Electricity uses path of least resistance

To reduce:
- Electric shock
- Equipment damage
- Time lost during repair
- Cost
Ground and Over Current Protection

**OCP, breakers**
- 10 amp circuit
- 15 amp
- 25 amp
- 50 amp
- Require ground

**GFCI**
- 4-6 milli-amps
- Less than 40 milliseconds
- Don’t require ground
Ground Fault Circuit Interrupters vs. OCP

Both are switches

OverCurrent Protection Trips when?

- GFCI trip 4-6 mA and 1/40 second
Current Level

- Breakers eliminate or minimize damage
- Outbound current is compared to return current
- Measures the **difference in current**
- GFCI protects from electrocution by paralysis

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**Current Magnitudes**

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<th>DC Current</th>
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<tbody>
<tr>
<td>0-4 mA</td>
<td>Perception Threshold</td>
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<tr>
<td>4.15 mA</td>
<td>Surprise</td>
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<tr>
<td>5-80 mA</td>
<td>Reflex Action</td>
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<tr>
<td>80-160 mA</td>
<td>Muscular Inhibition</td>
</tr>
<tr>
<td>160-300 mA</td>
<td>Respiratory Failure</td>
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<tr>
<td>&gt;300 mA</td>
<td>Usually Fatal</td>
</tr>
</tbody>
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Misconception

- I won’t get a shock
- Oh yes, I will!
Portable GFCI outlets, plugs into any outlets. Must say is “waterproof”.
National Electrical Code and OSHA

Require GFCI in all **wet area** circuits
Both Inside and Outdoors
**Documented** monthly tests

GFCI trip 4-6 mA and 1/40 second
Safe Work Practices

- May be free!
- Teach every person
- Never assume they know
- Best Management Practices
Safe work practices

- Close panels
- Clean dust out of panels
- Minimize extension cords
- Squeegee floors
- Reduce water
- Dust off electrical equipment
Poor design of adjustments
Electrical maintenance

- Clean dust out of breaker panels
- Friend had 2 dust fires in breaker panels
- Procedure to check and clean regularly
- Shut off power to the panel
Safe practices for less than a couple bucks

- Machine guards limit travel of splash.
- De-energize all electrical
- Verify it’s de-energized
- Lockout
- Always assume power is turned on:
  - Chris was told it was de-energized
    - BELIEVED, so didn’t verify
    - THEN IT zapped HIM
    - SHOCKING!
Safety by design
Adding outlets

Hard wired or plug-in
Support entire cord with cable to plug end
Avoid use of extension cord

- Short cord with waterproof plug (this one plugs into the hanging cord)
- Long cord out of wet area
Correct motor on transfer pump?

Inverter Duty Motor
• Dust?

• Dust?
Explosion proof vs water tight
Emergency motor shut off

- Motor’s power disconnect is “within sight of” the motor.
- OSHA says **this “within sight”** is less than 50 feet.
- Disconnect is “easy to reach”
- Clearly indicates (off) or (on)
- If mounted vertical, (off) is always down
Accessible disconnects and outlets
IP: Ingress Protection for sensors

- **6** is dust tight

- 2nd digit is **water ingress**:
  - **IP65**: low pressure spray with limited ingress.
  - **IP66**: strong jets with limited ingress.
  - **IP67**: 30 min. immersion without ingress.
  - **IP68**: submerge without water ingress.
  - **IP69K**: high pressure, high temp wash-downs, as in food processing.
Water proof? versus explosion proof
Hazardous location

Hazardous Location Conditions:
Class II is the second type of hazardous location
“Sufficient quantities of combustible dust to be explosive or ignitable”

Class II locations for combustible dust, and then:
• Group G = grain dusts...
## NEMA Enclosure ratings

<table>
<thead>
<tr>
<th>Type of Enclosure</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>4X</th>
<th>5</th>
<th>6</th>
<th>6P</th>
<th>12</th>
<th>12K</th>
<th>13</th>
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<tbody>
<tr>
<td>Access to hazardous parts</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Ingress of solid foreign objects (falling dirt)</td>
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<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Ingress of solid foreign objects (circulating dust, lint, or fibers)</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Ingress of solid foreign objects (settling airborne dust, lint, or fibers)</td>
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<td>Ingress of water (hose down and splashing)</td>
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<td>Oil or coolant spraying and splashing</td>
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<td>Ingress of water (temporary submersion)</td>
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<td>Ingress of water (prolonged submersion)</td>
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### IEC

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</table>


Note: Use this chart to convert NEMA to IP, but not IP to NEMA.
Wash down duty

- Wash down duty motors are not air-tight.
- Have condensate drain holes
- Holes breathe as they heat and cool
- If the drain holes are up, water runs in
- You can get shocked
- “…wash down isn’t wash down!” - Simmons
UL 508A

- Industrial control panels
- Spacing of components
- Calculates for heat created
- To minimize, dissipate component heat
- Limit potential for fire
- Increase life of components
UL508A helps equipment last

- Too small for heat and trips
- Has to run with door open
- Oversized so equipment is cool
- Runs without a hiccup
Hot Circuits and electrical maintenance
Flying lead impacting other wires
Ask questions to:
Brewery.safety.consulting@gmail.com
BA Forum: attn Safety subcommittee

Thanks to:

- Dry Dock Brewing
- Station 26 Brewing
- Upslope Brewing
- Pagosa Brewing
- Sleeping Giant
- Ska Brewing

- OSHA 1910
- OSHA 1926
- Red Rocks CC OSHA Institute
- BA Safety Subcommittee team
- My wife