DCFluX in: The Man with the Soldering Gun

Presented By:
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Chief Engineer, New West Broadcasting Systems, Inc.

DEFCON 17
Las Vegas, NV
Thursday July 30, 2009; 16:00 – 16:50
The following presentation has been edited to run in the time allotted.
Thank you, Sir/
Hidden Agenda

1. Safety
2. Solder
3. FluX on: Flux
4. Soldering & Desoldering Tools
5. Soldering & Desoldering Demonstration
6. Editorial
1. Safety

WARNING

DON'T SOLDER
WHILE
YOU'RE NAKED
Recommended Safety Procedures

• Safety Glasses or Face Shield
• Non-Synthetic Clothes
• Long Sleeves or Sleeve Extensions
• Fume Extractor
• Wash Hands After Touching Solder
• Use Flexible Drinking Straws
1. Safety

Don’t do what DCFluX does

• Low quality solder
• Solder in mouth
• Small soldering iron
• Burnt pinky finger
• Breathing fumes
• Synthetic blend pants
• Soldering over ‘The Package’

Photo By: Martin Rudolph
2. Solder

What is Solder?

1: a metal or metallic alloy used when melted to join metallic surfaces; especially: an alloy of lead and tin so used

http://www.merriam-webster.com/dictionary/solder
2. Solder

Soldering / Brazing / Welding

- > 840°F = Soldering
- 840° - 1200°F = Brazing
- 1200 - 6000°F = Welding
2. Solder

RoHS: Reduction of Hazardous Substances

- Lead
- Mercury
- Cadmium
- Hexavalent Chromium
- Polybrominated Biphenyls
- Polybrominated Diphenyl Ether

http://www.oehha.ca.gov/prop65/prop65_list/files/P65single061909.pdf
2. Solder

Regular vs. Unleaded

Lead is a soft metal that easily rubs off. Lead is poisonous and constant exposure is known to cause brain damage.
2. Solder

Regular vs. Unleaded

• Substances known to cause cancer in the state of California
  – Lead
  – Cadmium
  – Beryllium Oxide
  – Ethyl Alcohol (alcoholic beverages)
  – Marijuana Smoke

http://www.oehha.ca.gov/prop65/prop65_list/files/P65single061909.pdf
2. Solder

Regular vs. Unleaded

- Tin Plague (Tin Pest)

Photo By: DCFluX
2. Solder

Regular vs. Unleaded

• Tin Whiskers

Photos By: NASA and Tracey Hooker
2. Solder

Regular vs. Unleaded

- Tin Whisker Failures

Photos By: Boeing and Claremont Corporation
2. Solder

Regular vs. Unleaded

- Tin Solder Failures

Photo By: Microsoft Corporation
2. Solder

Solderability of Metals

- Excellent: Platinum, Gold, Silver, Tin, Copper, Beryllium-Copper
- Good: Bronze, Brass, Lead, Nickel, Nickel-Silver, Cadmium, Palladium, Rhodium
- OMG!: Zinc, Caron Steels, Galvanized Steel, Low-Alloy Steels
- WTF?: Aluminum, Chromium, Titanium, Tantalum, Magnesium, Cast Iron, Stainless Steel
Who makes Solder?

- Kester
- Multicore
- American Iron and Metal (AIM)
- MG Chemicals
- Indium Corporation of America
- American Tin and Solder
Available forms of Solder

- Wire – 0.015” – 0.200”
- Bar – 1.66 lbs.
- Paste – 2 oz. – 1 lb.
- Spheres
- Preforms
Available forms of Solder

- Through hole components & wire
  - Wire, 0.025” – 0.04”; Solder bath; Preforms
- Surface mount technology (Visible)
  - Wire, 0.015”; Paste
- Surface mount technology (Invisible)
  - Spheres
- Copper pipe & plates
  - Wire, 0.125”
# Metals used in Solder & Electronics

<table>
<thead>
<tr>
<th>Metal</th>
<th>Sn&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Pb&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Bi&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Sn&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Pb&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Bi&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Sn&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Pb&lt;sub&gt;100&lt;/sub&gt;</th>
<th>Bi&lt;sub&gt;100&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tin - Sn&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>232°</td>
<td>450°</td>
<td>115 nΩ</td>
<td>22.0 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lead - Pb&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>327°</td>
<td>621°</td>
<td>208 nΩ</td>
<td>28.9 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Antimony - Sb&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>604°</td>
<td>1167°</td>
<td>417 nΩ</td>
<td>11.0 μm</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Gold - Au&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>1064°</td>
<td>1948°</td>
<td>22.14 nΩ</td>
<td>14.2 μm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Silver - Ag&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>962°</td>
<td>1763°</td>
<td>15.87 nΩ</td>
<td>18.9 μm</td>
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<tr>
<td><strong>Copper - Cu&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>1085°</td>
<td>1984°</td>
<td>17.24 nΩ</td>
<td>16.5 μm</td>
<td></td>
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<tr>
<td><strong>Zinc - Zn&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>420°</td>
<td>787°</td>
<td>59.0 nΩ</td>
<td>30.2 μm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Bismuth - Bi&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>271°</td>
<td>521°</td>
<td>1290 nΩ</td>
<td>13.4 μm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Indium - In&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>157°</td>
<td>314°</td>
<td>71.8 nΩ</td>
<td>32.1 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cadmium - Cd&lt;sub&gt;100&lt;/sub&gt;</strong></td>
<td>321°</td>
<td>610°</td>
<td>72.7 nΩ</td>
<td>30.8 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Regular Solder Alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn&lt;sub&gt;63&lt;/sub&gt;Pb&lt;sub&gt;37&lt;/sub&gt;</td>
<td>183°</td>
<td>361°</td>
<td>205 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;60&lt;/sub&gt;Pb&lt;sub&gt;40&lt;/sub&gt;</td>
<td>183° - 190°</td>
<td>361° - 374°</td>
<td>149 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;50&lt;/sub&gt;Pb&lt;sub&gt;50&lt;/sub&gt;</td>
<td>183° - 214°</td>
<td>361° - 420°</td>
<td>158 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;10&lt;/sub&gt;Pb&lt;sub&gt;90&lt;/sub&gt;</td>
<td>268° - 302°</td>
<td>514° - 576°</td>
<td>194 nΩ</td>
<td>700° - 900°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;5&lt;/sub&gt;Pb&lt;sub&gt;95&lt;/sub&gt;</td>
<td>301° - 314°</td>
<td>574° - 597°</td>
<td>196 nΩ</td>
<td>800° - 900°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;62&lt;/sub&gt;Pb&lt;sub&gt;36&lt;/sub&gt;Ag&lt;sub&gt;2&lt;/sub&gt;</td>
<td>179° - 189°</td>
<td>354° - 372°</td>
<td>114 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;10&lt;/sub&gt;Pb&lt;sub&gt;88&lt;/sub&gt;Ag&lt;sub&gt;2&lt;/sub&gt;</td>
<td>268° - 299°</td>
<td>565° - 574°</td>
<td>203 nΩ</td>
<td>800° - 900°</td>
</tr>
</tbody>
</table>

**Sn** = Tin  
**Pb** = Lead  
**Sb** = Antimony  
**Ag** = Silver  
**Cu** = Copper  
**Zn** = Zinc  
**Bi** = Bismuth  
**In** = Indium  
**Cd** = Cadmium
## Unleaded Solder Alloys

<table>
<thead>
<tr>
<th></th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn&lt;sub&gt;100&lt;/sub&gt;</td>
<td>232°</td>
<td>450°</td>
<td>115 nΩ</td>
<td>700° - 800°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;95&lt;/sub&gt;Sb&lt;sub&gt;5&lt;/sub&gt;</td>
<td>232° - 240°</td>
<td>450° - 464°</td>
<td>145 nΩ</td>
<td>700° - 900°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;96&lt;/sub&gt;Ag&lt;sub&gt;4&lt;/sub&gt;</td>
<td>221° - 229°</td>
<td>430° - 444°</td>
<td>123 nΩ</td>
<td>700° - 800°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;96.5&lt;/sub&gt;Ag&lt;sub&gt;3.5&lt;/sub&gt;</td>
<td>221°</td>
<td>430°</td>
<td>107 nΩ</td>
<td>700° - 800°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;96.5&lt;/sub&gt;Ag&lt;sub&gt;3.0&lt;/sub&gt;Cu&lt;sub&gt;0.5&lt;/sub&gt;</td>
<td>217° - 220°</td>
<td>422° - 428°</td>
<td>133 nΩ</td>
<td>700° - 800°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;95.5&lt;/sub&gt;Ag&lt;sub&gt;3.8&lt;/sub&gt;Cu&lt;sub&gt;0.7&lt;/sub&gt;</td>
<td>217° - 221°</td>
<td>422° - 430°</td>
<td>130 nΩ</td>
<td>700° - 800°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;99.3&lt;/sub&gt;Cu&lt;sub&gt;0.7&lt;/sub&gt;</td>
<td>227°</td>
<td>440°</td>
<td>132 nΩ</td>
<td>700° - 800°</td>
</tr>
</tbody>
</table>

Sn = Tin  
Pb = Lead  
Sb = Antimony  
Ag = Silver  
Cu = Copper  
Bi = Bismuth  
Zn = Zinc  
In = Indium  
Cd = Cadmium
# Zinc Solder Alloys

<table>
<thead>
<tr>
<th></th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn$<em>{91}$Zn$</em>{9}$</td>
<td>199°</td>
<td>390°</td>
<td>115 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn$<em>{89}$Zn$</em>{8}$Bi$_{3}$</td>
<td>191° - 198°</td>
<td>376° - 388°</td>
<td></td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn$<em>{45}$Pb$</em>{53}$Zn$_{2}$</td>
<td>170° - 215°</td>
<td>338° - 419°</td>
<td></td>
<td>600° - 800°</td>
</tr>
<tr>
<td>Sn$<em>{40}$Pb$</em>{58}$Zn$_{2}$</td>
<td>175° - 220°</td>
<td>347° - 428°</td>
<td></td>
<td>600° - 800°</td>
</tr>
</tbody>
</table>

Sn = Tin  
Pb = Lead  
Sb = Antimony  
Ag = Silver  
Cu = Copper  
Bi = Bismuth  
In = Indium  
Zn = Zinc  
Cd = Cadmium
# Low Heat Solder Alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn&lt;sub&gt;67.8&lt;/sub&gt;Cd&lt;sub&gt;32.2&lt;/sub&gt;</td>
<td>176°</td>
<td>349°</td>
<td></td>
<td>500° - 600°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;60&lt;/sub&gt;Bi&lt;sub&gt;40&lt;/sub&gt;</td>
<td>138° - 170°</td>
<td>280° - 338°</td>
<td>345 nΩ</td>
<td>500° - 600°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;48&lt;/sub&gt;In&lt;sub&gt;52&lt;/sub&gt;</td>
<td>118°</td>
<td>244°</td>
<td>147 nΩ</td>
<td>500°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;42&lt;/sub&gt;Bi&lt;sub&gt;58&lt;/sub&gt;</td>
<td>138°</td>
<td>281°</td>
<td>359 nΩ</td>
<td>500° - 600°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;42&lt;/sub&gt;Bi&lt;sub&gt;57&lt;/sub&gt;Ag&lt;sub&gt;1.0&lt;/sub&gt;</td>
<td>137° - 139°</td>
<td>279° - 282°</td>
<td></td>
<td>500° - 600°</td>
</tr>
<tr>
<td>In&lt;sub&gt;100&lt;/sub&gt;</td>
<td>157°</td>
<td>314°</td>
<td>71.8 nΩ</td>
<td>500°</td>
</tr>
<tr>
<td>In&lt;sub&gt;97&lt;/sub&gt;Ag&lt;sub&gt;3&lt;/sub&gt;</td>
<td>143°</td>
<td>290°</td>
<td>74.9 nΩ</td>
<td>500° - 600°</td>
</tr>
</tbody>
</table>

Sn = Tin  
Ag = Silver  
Bi = Bismuth  
Pb = Lead  
Cu = Copper  
In = Indium  
Sb = Antimony  
Zn = Zinc  
Cd = Cadmium
## Removal Alloys

<table>
<thead>
<tr>
<th>Alloys</th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Sn}<em>{12}\text{Pb}</em>{18}\text{In}<em>{21}\text{Bi}</em>{49}$</td>
<td>58°</td>
<td>136°</td>
<td>710 nΩ</td>
<td>500°</td>
</tr>
<tr>
<td>Chip Quik ®</td>
<td>58°</td>
<td>136°</td>
<td></td>
<td>500°</td>
</tr>
<tr>
<td>$\text{Sn}<em>{18}\text{Pb}</em>{28}\text{Cd}<em>{11}\text{Bi}</em>{43}$</td>
<td>58°</td>
<td>136°</td>
<td></td>
<td>500°</td>
</tr>
<tr>
<td>(No Pb) Chip Quik ®</td>
<td>58°</td>
<td>136°</td>
<td></td>
<td>500°</td>
</tr>
<tr>
<td>$\text{Sn}<em>{30}\text{Bi}</em>{56}\text{In}_{14}$</td>
<td>58°</td>
<td>136°</td>
<td></td>
<td>500°</td>
</tr>
</tbody>
</table>

**Symbols:****

- **Sn** = Tin
- **Pb** = Lead
- **Sb** = Antimony
- **Ag** = Silver
- **Cu** = Copper
- **Zn** = Zinc
- **Bi** = Bismuth
- **In** = Indium
- **Cd** = Cadmium
# Solder Alloys You Will Actually Use

<table>
<thead>
<tr>
<th>Solder Alloy</th>
<th>Melting °C</th>
<th>Melting °F</th>
<th>Resistivity</th>
<th>Tip °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn&lt;sub&gt;63&lt;/sub&gt;Pb&lt;sub&gt;37&lt;/sub&gt;</td>
<td>183°</td>
<td>361°</td>
<td>149 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;60&lt;/sub&gt;Pb&lt;sub&gt;40&lt;/sub&gt;</td>
<td>183° - 190°</td>
<td>361° - 374°</td>
<td>205 nΩ</td>
<td>600° - 700°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;62&lt;/sub&gt;Pb&lt;sub&gt;36&lt;/sub&gt;Ag&lt;sub&gt;2&lt;/sub&gt;</td>
<td>179° - 189°</td>
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<td>114 nΩ</td>
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</tr>
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<td>Sn&lt;sub&gt;50&lt;/sub&gt;Pb&lt;sub&gt;50&lt;/sub&gt;</td>
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</tr>
<tr>
<td>Sn&lt;sub&gt;95&lt;/sub&gt;Sb&lt;sub&gt;5&lt;/sub&gt;</td>
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<td>700° - 900°</td>
</tr>
<tr>
<td>Sn&lt;sub&gt;96.5&lt;/sub&gt;Ag&lt;sub&gt;3.0&lt;/sub&gt;Cu&lt;sub&gt;0.5&lt;/sub&gt;</td>
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</tr>
<tr>
<td>Sn&lt;sub&gt;99.3&lt;/sub&gt;Cu&lt;sub&gt;0.7&lt;/sub&gt;</td>
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<td>132 nΩ</td>
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</tr>
</tbody>
</table>

Sn = Tin  
Pb = Lead  
Sb = Antimony  
Ag = Silver  
Cu = Copper  
Bi = Bismuth  
In = Indium  
Zn = Zinc  
Cd = Cadmium
What is Flux?

5: a substance used to promote fusion (as of metals or minerals); especially: one (as rosin) applied to surfaces to be joined by soldering, brazing, or welding to clean and free them from oxide and promote their union.

http://www.merriam-webster.com/dictionary/flux
What does Flux do?

• Cleans the surfaces to be joined
• Increases the flow of solder
  – Conducts heat to a degree
• Prevents oxidation during soldering
Available forms of Flux

- **Liquid**
  - Rosin, No clean rosin
  - Water soluble (Inorganic)

- **Paste**
  - Rosin
  - Acid

- **Cored Solder**
  - Rosin, No clean rosin
  - Water soluble (Organic & Inorganic)
  - Acid
What is Rosin?

1: a translucent amber-colored to almost black brittle friable resin that is obtained from the oleoresin or deadwood of pine trees or from tall oil and used especially in making varnish

http://www.merriam-webster.com/dictionary/rosin
<table>
<thead>
<tr>
<th>Flux Code</th>
<th>Type</th>
<th>Activation</th>
<th>Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘44’ (ROM1)</td>
<td>Rosin</td>
<td>Full</td>
<td>Solvent</td>
</tr>
<tr>
<td>‘48’ (ROM1)</td>
<td>Rosin</td>
<td>Full</td>
<td>Optional, Solvent</td>
</tr>
<tr>
<td>‘245’ (ROL0)</td>
<td>NC Rosin</td>
<td>Mild</td>
<td>No Clean</td>
</tr>
<tr>
<td>‘275’ (ROL0)</td>
<td>NC Rosin</td>
<td>Mild</td>
<td>No Clean</td>
</tr>
<tr>
<td>‘285’ (ROL0)</td>
<td>Rosin</td>
<td>Mild</td>
<td>Optional, Solvent</td>
</tr>
<tr>
<td>‘331’ (ORH1)</td>
<td>Organic</td>
<td>-</td>
<td>120°- 150°F Water</td>
</tr>
<tr>
<td>‘3350’ (INH1)</td>
<td>Acid</td>
<td>-</td>
<td>Neutralizer, Hot Water</td>
</tr>
</tbody>
</table>
Rosin Flux Solvents

- Flux remover
- Heavy duty Flux remover
- Denatured alcohol
- 50/50 Denatured alcohol and acetone
- Rubbing alcohol
- 50/50 Rubbing alcohol and unscented nail polish remover
Flux Removal Tools

- Tooth brush
- Cotton swab (Q-Tip)
- Chamois cloth
- Dental pick
4. Soldering & Desoldering Tools

Soldering Iron

Photo By: Weller
4. Soldering & Desoldering Tools

Soldering Stations

Photos By: Weller
4. Soldering & Desoldering Tools

Soldering Station Tips
4. Soldering & Desoldering Tools

Portable Soldering Irons

Photos By: Weller
4. Soldering & Desoldering Tools

Don’t do what DCFluX does

• Using a torch near ‘The Package’
4. Soldering & Desoldering Tools

Soldering Guns

Photos By: Weller
4. Soldering & Desoldering Tools

Hot Air Rework Stations

Photos By: Weller
4. Soldering & Desoldering Tools

Heat Guns

Photos By: Weller
4. Soldering & Desoldering Tools

Professional BGA Reflow Station

Photo By: Weller
4. Soldering & Desoldering Tools

Kitchen Top Reflow Station

Left Photo By: Spark Fun Electronics
What DCFluX uses

4. Soldering & Desoldering Tools
4. Soldering & Desoldering Tools

Solder Suckers

Photos By: Edsyn
4. Soldering & Desoldering Tools

Solder Wick

- Copper Braid
  - 0.025” – 1.5”
  - 5’ – 1000’ Rolls
  - Rosin, No clean rosin and Unfluxed

Photo By: Edsyn
4. Soldering & Desoldering Tools

Recommended Tools

- Relieved head diagonal cutting pliers
  - Flush cut
- Stainless steel tweezers & bulldogs
- Hemostats
- Metal IC remover
- Sponge
- 300-600 grit sand paper
- Pencil with eraser
5. Soldering & Desoldering Demonstration

Soldering Process Diagram

- **Preparation**
  - Clean surface of oxidation and or apply Flux if necessary

- **Soldering**
  - Apply heat to work
  - Allow work to come to temperature
  - Apply solder to work

- **Completion**
  - Allow solder joint to cool down
  - Clean Flux Residue
  - Inspect quality of joint
6. Editorial

Cyanoacrylate Does Not Conduct

Photos By: Super Glue Corp. and Krazy Glue
Aluminum solder doesn’t work for me

Photos By: BernzOMatic and Solder-It Co.
6. Editorial

Aluminum + Electricity = Evil

Photo By: DCFluX
CADWELD® is awesome

Photo By: DCFluX
This thing sucks

Photo By: Ilikefood
6. Editorial

This thing too

Photo By: Weller
A good way to blow up your USB ports
Cheap and effective
Amateur Dentist™ Hobby Kit

Photo By: Radio Shack
6. Editorial

This is still a POS
Questions?
Track 2 Q&A Room
matt@kgmn.net
DCFluX will return in: Moonbouncer

Photos By: CSIRO and NASA