Resistance Welding Training

Welding Fundamentals
Resistance Welding Diagram:

**PROCESS**
Part Positioning, Electrode Maintenance, etc.

**OPTIMIZED SETTINGS & MONITORING**

**WELDING SUCCESS**

**MATERIAL CONTROL**

**EQUIPMENT**
Power Supply, Weld Head, Electrodes, etc.

**MATERIALS**
Composition, Plating, Hardness, Geometry, etc.

**EQUIPMENT SELECTION**
Let’s Start With Some Definitions: How Does it Work?

- **Current is passed through the parts to generate heat at the weld interface**
  - decomposes dirt and grease
  - breaks up the oxide film
  - softens or melts the metals
- **The welding force holds the parts together**
  - The atoms on either side migrate to form a diffusion bond, or the metals melt and mix to form a fusion weld
  - strength develops as the joint cools (hold time)
Definitions: Basic Welding System

- Weld Current
- Time

- Force

- Low Voltage/High Current Secondary

Definitions:
- Basic Welding System
  - Power Supply
  - Transformer
  - Weld Head
Definitions: Advanced Welding Systems

- Closed Loop Control
- Energy, Force, and Displacement Monitoring
- Data Collection and Analysis
Definitions: Electrode Configurations

- **Opposed (Direct)**
- **Step Weld (Indirect)**
- **Series Weld (Parallel Gap)**
Common Part Geometries

- Flat
- Round
- Round /Flat
- Projection
Types of Bonds

**Fusion**
Both metals melt and mix.

**Solid-State**
Bring temperature up to 70-80% of melting point.

**Solder or Braze**
(Solder <400°C m.p. Filler)
(Braze >400°C m.p. Filler)
*Note: Sil-phos is a common brazing material.*
Fusion Weld Video:
Weld Heat Formula

Weld Heat = $I^2Rt - \text{Thermal Loss}$

where:

$I = \text{weld current, amperes}$

$R = \text{resistance of work pieces, ohms}$

$t = \text{duration of current, seconds}$

Note:

Thermal Loss is the heat sinking into the parts, electrodes and tooling.
Weld Heat Formula for Different Feedback Modes:

\[
\text{Weld Heat} = (I^2 \times R) \times t - \text{Thermal Loss}
\]

\[
= (V^2/R) \times t - \text{Thermal Loss}
\]

\[
= (I \times V) \times t - \text{Thermal Loss}
\]

\[
= \text{(Power)} \times t - \text{Thermal Loss}
\]

\[
= \text{Energy} - \text{Thermal Loss}
\]
Contact and Bulk Resistance
How Resistance Affects Heat Distribution

Contact Resistance

Bulk Resistance

Time

Contact Resistance

Bulk Resistance

Time

Heat Affected Zone
Bonding temperature of materials (different for solid-state vs. fusion welds).
Basic Welding Schedule

- Weld strength is developed during Hold Time.
- Basic Welding Schedule is sufficient for 90% of the applications.
Resistance Welding Diagram:

**PROCESS**
Part Positioning, Electrode Maintenance, etc.

**EQUIPMENT**
Power Supply, Weld Head, Electrodes, etc.

**MATERIALS**
Composition, Plating, Hardness, Geometry, etc.

**OPTIMIZED SETTINGS & MONITORING**

**WELDING SUCCESS**

**MATERIAL CONTROL**
The first question - What are the materials?

- Material Properties:
  Electrical and thermal conductivity, melting point, hardness, and welding compatibility

- Surface Conditions:
  Plating, oxides, roughness, insulation, and contamination

- Physical Part Design:
  Size, shape, and access to welding area
## Dissimilar Materials

<table>
<thead>
<tr>
<th></th>
<th>Group I (Conductive)</th>
<th>Group II (Resistive)</th>
<th>Group III (Refractive)</th>
</tr>
</thead>
</table>
| Group I (Conductive) | • Solid-State  
• Braze or Solder | • Solid-State  
• Projection on Group I | • Solid-State  
• Fine projections on Group III |
| Group II (Resistive) | • Solid-State or Fusion  
• Easiest to Weld | | • Solid-State  
• Braze  
• Projection on III |
| Group III (Refractive) | | | • Solid-State  
• Braze |
## Weldability Chart

<table>
<thead>
<tr>
<th>Material</th>
<th>Weldability Code</th>
<th>Designing Parts for Weldability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Molybdenum (2000°) &amp; Tungsten (3400°)</td>
<td>2/3</td>
<td>Consider the melting point and thermal conductivity.</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>4</td>
<td>In general, reactive partners should be considered.</td>
</tr>
<tr>
<td>Phosphor Bronze (900°)</td>
<td>5</td>
<td>Balance the thermal mass.</td>
</tr>
<tr>
<td>Niobium (2470°)</td>
<td>6</td>
<td>If the thermal mass is not balanced, design parts for easy electrode access.</td>
</tr>
<tr>
<td>Nickel (1450°)</td>
<td>7</td>
<td>Weldability may be necessary.</td>
</tr>
<tr>
<td>Cold Rolled Steel (1450°)</td>
<td>8</td>
<td>Short weld times may be possible.</td>
</tr>
<tr>
<td>Brass (900°)</td>
<td>9</td>
<td>Use power supply with a low inductance to shorten weld times.</td>
</tr>
<tr>
<td>Beryllium Copper (980°)</td>
<td>10</td>
<td>Use power supply with a low inductance to shorten weld times.</td>
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<tr>
<td>Aluminum (660°)</td>
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<td>Copper (1000°)</td>
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<tr>
<td>Tungsten (3400°)</td>
<td>13</td>
<td>Use power supply with a low inductance to shorten weld times.</td>
</tr>
</tbody>
</table>

### Electrode Materials

- **A** - Graphite - 12% Al Oxide Dispersion-Strengthened Copper. Long life, high strength electrodes primarily for welding reactive parts.
- **B** - RWMA2 - Copper Chromium Alloy. Used for welding steels, nickel alloys, and other reactive parts.
- **C** - RWMA3 - Copper Cobalt Beryllium Alloy. Used for welding reactive parts requiring high welding forces.
- **D** - RWMA11 - Copper Tungsten Alloy. Used for welding cuprous and precious metals.
- **E** - RWMA13 - Tungsten. Usually inserted into RWMA2 Shank. Very hard. Used to weld non-ferrous metals such as copper and brass.
- **F** - RWMA4/5 - Molybdenum. Usually inserted into RWMA2 Shank. Used for welding copper, silver, gold, and their alloys.

### Comments

- **a** - High joint possible.
- **b** - Use power supply with a low inductance to shorten weld times.
- **c** - Low joint possible.
- **d** - Electrode occurs.
- **e** - Short weld necessary.
## Electrode Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Conductivity (IACS)</th>
<th>Hardness (Rockwell)</th>
</tr>
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<tbody>
<tr>
<td>Glidcop AL-15</td>
<td>Dispersion Strengthened Copper (0.15% Al Oxide)</td>
<td>92%</td>
<td>68B</td>
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<tr>
<td>RWMA 2</td>
<td>Copper Chromium</td>
<td>85%</td>
<td>83B</td>
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<tr>
<td>RWMA 3</td>
<td>Copper Cobalt Beryllium</td>
<td>48%</td>
<td>100B</td>
</tr>
<tr>
<td>RWMA 11</td>
<td>Copper Tungsten</td>
<td>46%</td>
<td>99B</td>
</tr>
<tr>
<td>RWMA 13</td>
<td>Tungsten</td>
<td>32%</td>
<td>70A</td>
</tr>
<tr>
<td>RWMA 14</td>
<td>Molybdenum</td>
<td>31%</td>
<td>90B</td>
</tr>
</tbody>
</table>

RWMA: Resistance Welder Manufacturers’ Association  
IACS: International Annealed Copper Standard
Part Surface Conditions

- Plating Inconsistencies
- Surface Roughness
- Oxidation
- Contamination

Surface conditions must be addressed prior to or during welding.
Design for Weldability

Consider part size, shape, and access to the welding area
Use of Weld Projections

- **Promotes Heat Balance:**
  - Reduces thermal mass of thicker piece
  - Increases current density
  - Increases part interface resistance

- **Extends Electrode Life:**
  - Larger electrode face can be used

- **Ensures Current Path:**
  - Minimizes effects of shunting
Resistance Welding Diagram:

- **PROCESS**
  - Part Positioning, Electrode Maintenance, etc.

- **EQUIPMENT**
  - Power Supply, Weld Head, Electrodes, etc.
  - Optimized Settings & Monitoring
  - Equipment Selection

- **MATERIALS**
  - Composition, Plating, Hardness, Geometry, etc.
  - Material Control
Power Supply Technologies:

- **High Frequency Inverter (HF)**
- **Linear DC**
- **Capacitor Discharge (CD)**
  - "Stored Energy"
- **Direct Energy (A.C.)**
High Frequency (HF) Attributes

Characteristics:
- Energy control in Current, Voltage, or Power
- Time control in 0.1 millisecond increments (minimum)
- High Repetition Rates
- Closed Loop Feedback - Compensates for varying part conditions
- Built-in Monitor

Applications and Use:
Linear DC Attributes

Characteristics:
- Energy control in Current, Voltage, or Power
- Time control in 0.01 millisecond increments (minimum)
- Low Repetition Rates
- Closed Loop Feedback - Compensates for varying part conditions
- Built-in Monitor

Applications and Use:
Ultra stable waveform. Extends electrode life. Best choice for welding fine wires and thin foils.
Single Pulse

- Energy control in % Energy or Watt-Seconds
- Time control in Pulse Widths
- Low Repetition Rates
- Open Loop - No Feedback
- Lacks true upslope control

Applications and Use:
Fast rise time with high peak current. Good for welding flat conductive parts. Requires good part fit up.

Dual Pulse

Pulse Width Adjustment
Direct Energy (A.C.) Attributes

Characteristics:
- Coarse energy control with transformer taps
- Fine energy control in % Current
- Time control in Line Cycles
- High Repetition Rates
- Open Loop - No Feedback
- Susceptible to Line Voltage Fluctuations
- Weld cools between ½ cycles

Applications and Use:
General purpose, lower cost welders with high energy output. Longer weld times useful for brazing applications.
Advantages of Closed Loop

- Repeatable Output
- Upslope Control
- Longer Electrode Life
- Feedback Modes
- Built In Monitoring
- Process Tools
- Displacement and Force Monitoring (HF27)
- SPC
A Closed Loop power supply will keep the programmed parameter constant (Current, Voltage, or Power).

The non-programmed parameter will change based on the work piece resistance, which can vary with part or process conditions.
Repeatable Output

The same current is delivered, but the voltage adapts to the difference in work piece resistance.

Weld 1:

Weld 2:
Upslope Control

Contact Resistance

Bulk Resistance

Heat Affected Zone

Time

Resistance
 Longer Electrode Life

➢ Which set of electrodes will last longer?
➢ Why?
Feedback Modes

**Constant Voltage:**
- Compensates for parts misplacement and force problems
- Reduces weld splash
- Ideal for projection welds
- Monitor current

**Constant Power:**
- Varies current and voltage for consistent energy
- Breaks up surface oxides and plating
- Extends electrode life in automation
- Monitor current or voltage

**Constant Current:**
- Delivers same current regardless of resistance changes
- Compensates for part thickness changes
- Welding flat parts with consistent electrode to part fit-up
- Monitor voltage
## Feedback Modes

<table>
<thead>
<tr>
<th>Feedback Mode</th>
<th>Part Challenges</th>
<th>Process Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Voltage</td>
<td>Projections</td>
<td>Part Misplacement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Varying Overlap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inconsistent Force</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mushroomed Electrodes</td>
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<tr>
<td>Constant Power</td>
<td>Surface Roughness</td>
<td>Oxidized Electrodes</td>
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<td></td>
<td>Plating</td>
<td>Automated Systems</td>
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<tr>
<td></td>
<td>Inconsistencies</td>
<td></td>
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<tr>
<td></td>
<td>Oxidized Parts</td>
<td></td>
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<td></td>
<td>Contamination</td>
<td></td>
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<tr>
<td>Constant Current</td>
<td>Stacked Flat Parts,</td>
<td>Weld Cable Problems</td>
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<tr>
<td></td>
<td>Thickness Inconsistencies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wire Weld

Beginning of Weld  High Contact Resistance

Wires Deform  Reduced Contact Resistance

Parts Melt  Severe Resistance Drop
Use Constant Current with Upslope:

**Upslope** addresses the high contact resistance in the beginning of the weld. **Constant Current** addresses the severe resistance drop in the end of the weld.
Built In Monitoring

Graphic waveform traces (DC25, UB25, HF25, HF27) provide:

– Simple, dynamic weld information for process understanding and diagnostics
– Easy set limits with programmable relay action
– Other process tools
  • Pre-Weld Check
  • A.P.C.
  • Resistance Set
  • Weld to Limit
  • Weld Stop
Process Tools

Pre Weld Check

Active Part Conditioner / Resistance Set

Weld to a Limit

Weld Stop
Advanced Process Tools (HF27)

Combo Mode:

Energy Monitor:

Time Limits:
Defining a complete weld signature:

- Part heating
- Weld start
- Weld development
- Weld completion
Displacement Monitoring (HF27)

- **Uses:**
  - Part Detection
  - Measure Weld Collapse
  - Weld To Displacement

- **Ideal for Conductive Parts:**

  When welding conductive parts, the bulk resistance of the electrodes is typically much greater than the resistance of the parts, so monitoring the electrical changes may be difficult. Displacement monitoring is preferred.
Displacement Monitoring (HF27)

Comprehensive process monitoring combines the mechanical and electrical characteristics of the weld.
Force Monitoring (HF27)

Force can be monitored using a Load Cell:
Multiple Relay Outputs
External Monitoring:

MG3 Process Sentry:
Statistical Process Control

- RS-232 or RS-485 transmission of weld data to a P.C.
  - Identify Process Trends
  - Record Keeping
  - Quality Reporting

- S.P.C. software packages can generate control charts and provide data summaries
Weld Head Actions:

- Approach
- Impact
- Squeeze
- Fire
- Follow-up
- Hold
Weld Head Video:

Follow-up Force:

Video Loading...
Weld Head Video:

Insufficient Follow-up Force:

Video Loading...
How Electrode Force Affects Contact Resistance:

Low Force Causes High Contact Resistance

High Force Causes Low Contact Resistance
Poor Force Control Results in:

- Weld Splash
- Excessive part deformation
- Reduced electrode life
- Inconsistent weld heat
- Wide variations in weld strength
Weld Strength Profile:

Weld .032 dia. copper/tin wire to .010x.031 nickel ribbon

Energy (W•S)

Pull Strength (lbs)

Weld Force Curves

- 14 lbs
- 12 lbs
- 10 lbs
- 8 lbs

δPs

δE
Weld Head Actuation Methods:

- **Manual**
  - Foot Pedal & Coil Spring

- **Pneumatic**
  - Direct Air
  - Coil Spring
  - Proportional Pressure Control
  - EZ-AIR

- **Cam Driven**
  - Automation
- **Servo Motor**
- **Electro Magnetic**
Electrode Force vs. Time for Force Fired Weld Head

- **Electrode Force**
- **Final Force**
- **Firing Force**
- **Weld Current**
- **Squeeze Time**
- **Hold Time**

Time
Electrode Force vs. Time for Two Different Operators

Electrode Force

Final Forces

Firing Force

Squeeze Time

Weld Current

Hold Time

Time
EZ-AIR™ Overforce Protection:

- Fixed 78 psi Regulator
- Solenoid No. 1
- Solenoid No. 2
- Solenoid No. 3
- Air Cylinder
- Exhaust

Shop Air: 85 to 130 psi
Electrode Force vs. Time
Before and After EZ-AIR:
Motorized Weld Heads

Program positions & speed for soft touch part clamping & controlled approach speed

← Home
← Upstop
← Search Point
← Downstop
Electro-magnetic Weld Heads

Programming Screen:

Weld to Displacement/Set Limits:
Electrode Design

- Use constant area tip design
- Avoid pointed tips
- Avoid long narrow tips

Electrode face after cleaning:
- No change in heating
- Increasing area = colder weld

< 6 mm
Resistance Welding Diagram:

- **PROCESS**
  - Part Positioning, Electrode Maintenance, etc.

- **EQUIPMENT**
  - Power Supply, Weld Head, Electrodes, etc.

- **MATERIALS**
  - Composition, Plating, Hardness, Geometry, etc.

- **OPTIMIZED SETTINGS & MONITORING**

- **MATERIAL CONTROL**

The diagram illustrates the interplay between equipment, process, and materials to achieve welding success.
## Process Audit Worksheet

**General:**
- **Audited By:** [Field]
- **Date:** [Field]
- **Plant:** [Field]
- **Station Number:** [Field]
- **Job Number:** [Field]
- **Power Supply Model:** [Field]
- **S/N:** [Field]
- **Initiation:** [Field]

**Weld Head Model:** [Field]
- **S/N:** [Field]

### Weld Materials:

<table>
<thead>
<tr>
<th>Material 1</th>
<th>Top</th>
<th>Material 2</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td></td>
<td>Name:</td>
<td></td>
</tr>
<tr>
<td>Part Number:</td>
<td></td>
<td>Part Number:</td>
<td></td>
</tr>
<tr>
<td>Base Material:</td>
<td></td>
<td>Base Material:</td>
<td></td>
</tr>
<tr>
<td>Plating Type:</td>
<td></td>
<td>Plating Type:</td>
<td></td>
</tr>
<tr>
<td>Plating Thickness:</td>
<td></td>
<td>Plating Thickness:</td>
<td></td>
</tr>
<tr>
<td>Size:</td>
<td>mm Thick</td>
<td>Size:</td>
<td>mm Thick</td>
</tr>
<tr>
<td>Approved Source:</td>
<td></td>
<td>Approved Source:</td>
<td></td>
</tr>
</tbody>
</table>

### Weld Head:

| Electrode 1 | | Electrode 2 |
|-------------||-------------|
| Part Number: | | Part Number: |
| Material: | | Material: |
| Face Size: | mm | Face Size: | mm |
| Face Shape: | | Face Shape: | |
| Tip Length: | mm | Tip Length: | mm |
| Condition: | | Condition: | |
| Polarity: | | Polarity: | |
| Stroke: | mm | Stroke: | mm |
| Down Speed: | | Down Speed: | |
| Force Tube Setting: | | Force Tube Setting: | |
| Firing Force: | kg | Firing Force: | kg |
| Air Pressure Setting: | PSI | Air Pressure Setting: | PSI |
| Welding Force: | kg | Welding Force: | kg |
| Weld Cable Length: | | Weld Cable Length: | |
| Weld Cable Gauge: | | Weld Cable Gauge: | |
| Weld Cable Condition: | | Weld Cable Condition: | |
| V Sense Cable Mount: | | V Sense Cable Mount: | |
Optimizing the Welding Process

Look at welding applications from two different perspectives:

- **Application Perspective:** Balance the heat and find the “Weld Window”
- **Process Perspective:** Consider the challenges of the production environment
Application Perspective: Heat Balance & Optimization

- Consider material properties, surface conditions, and part design
- Choose starting point for equipment settings based on prior experience
- Experiment by making several sample welds
- Observe the heat balance by visual inspection and cross section (if required)
- Find “Weld Window” and “Corners of the Box”
- Optimize using monitor, heat balance techniques, and DOE
- Amend part design, add projections or change materials if required
Heat Balance Techniques

1) **Electrode Force**: Increase force to shift heat away from contact areas, decrease force to shift heat to contact areas.

2) **Upslope**: Increase upslope time to shift heat away from contact areas, decrease upslope time to shift heat to contact areas.

3) **Electrode Face Size**: Increase electrode face size to shift heat away from electrode, decrease face size to shift heat toward electrode.

4) **Polarity**: Depending on material combinations, heat may shift toward positive electrode.

5) **Electrode Materials**: Use more resistive electrode to shift heat toward electrode, use more conductive electrode to shift heat away from electrode.
Heat Balance Examples

Electrode size
Heat Balance Examples

Electrode size

Polarity
Heat Balance Examples

Electrode size

Polarity

Electrode Material
Heat Balance Examples

Electrode size

Polarity

Electrode Material
Weld Study:

Application: .032” Diameter Nichrome Wire; 90° Cross Wire Weld
Pull Strength vs. Current for 14, 16, 18, & 20 lbs Electrode Force:
**Pull Strength vs. Displacement:**

Application: .032” Diameter Nichrome Wire; 90° Cross Wire Weld:

<table>
<thead>
<tr>
<th>Electrode Force (lbs)</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
<th>1000</th>
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<td>24.4</td>
<td>33.8</td>
<td>54.6</td>
<td>47.2</td>
<td>54.6</td>
<td>61.4</td>
<td>62.8</td>
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<td>56.8</td>
<td>51.8</td>
<td>46.8</td>
<td>53.4</td>
</tr>
</tbody>
</table>

Weld Current (A): 400 500 600 700 800 900 1000

- Pull Strength of 60 lbs or Greater is Highlighted
- Displacement of .009” - .012” is Highlighted
Process Perspective: Production Welding & Monitoring

- How will operators handle and align the parts?
- What tooling or automation will be required?
- How will operators maintain and change the electrodes?
- Is electrode seasoning required?
- What other parameters will operators be able to adjust?
- What are the quality and inspection requirements?
- What are the relevant production testing methods, and monitoring requirements?
- Do we have adequate control over the quality of the materials?
90% of all welding process problems occur at the business end:

Material control  Part to part positioning  Electrode to part positioning

Result: Changes in heat balance....
Electrode Cleaning

- Use #600 or finer silicon carbide paper
- Use light electrode force
- Pull grit paper in one direction
- Rotate grit paper, look for concentric lines
- Replace electrode when tip is less than 1.5mm (.062”) long
- Replace electrode when tip blows out
- Best - Have shop re-grind electrode tips
Welcome to the Miyachi Unitek DoE Tool and Process Audit Worksheet.

Continue
Select Screening Factors:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Settings</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>Low 1.00</td>
<td>High 1.12 volt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Low 2.80</td>
<td>High 3.10 msec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td>Low 1.70</td>
<td>High 2.00 scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downslope</td>
<td>Low 1.00</td>
<td>High 3.00 msec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plating</td>
<td>regular</td>
<td>heavy mils</td>
</tr>
</tbody>
</table>

Strength

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strength (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
</tr>
<tr>
<td>Downslope</td>
<td></td>
</tr>
<tr>
<td>Plating</td>
<td></td>
</tr>
</tbody>
</table>

Strength Variation

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variation (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
</tr>
<tr>
<td>Downslope</td>
<td></td>
</tr>
<tr>
<td>Plating</td>
<td></td>
</tr>
</tbody>
</table>
Resistance Welding Troubleshooting

• Complete Process Audit Worksheet (PAW)
• Define the problem
• Understand the problem - heat balance
  – Probable causes
  – Use the monitor
• Use the troubleshooting guide
• Work through methodically
  – Start at the materials and work back through the system - “the 90% rule”
Troubleshooting Guide

**Instructions:**
- For the symptoms or problems, determine most likely cause and solution based on priority numbers with 1 as highest priority. Start troubleshooting with 1 and then proceed to 2 and so on. In cases where there are multiple causes with the same priority, use the following sequence for troubleshooting: MATERIAL RELATED, ELECTRODE RELATED, WELDHEAD RELATED, POWER SUPPLY RELATED.

**Basic Troubleshooting Rules (in order of priority):**
- Verify correct equipment set-up and line voltage; ensure all cables and other electrical connections are tight, replace broken fuses.
- Use clean electrodes and materials; Insure electrode alignment with flux parallel.
- Exercise consistent process control over materials, equipment and the weld.
- Check electrodes regularly and consistently using 600 grit paper or polishing disk (new lead).

As a general starting point, use shortest time, highest reasonable force and a weldhead with best follow-up and low mass electrode holders.

Follow instructions above to determine best course of action.

**If simplest solutions/adjustments fail:**
- Change only one variable at a time.
- If none variable does not resolve the problem, return it to its starting setting and try a second variable and then a third before changing two variables at once. Follow the scientific process of a controlled experiment.

If further assistance is needed, contact your local Miyachi Unitek Sales Representative or call the Factory Applications Lab at (626) 303-5676 for assistance.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Cause</th>
<th>Priority</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overheating of Weldment</td>
<td>Excess Current/Energy</td>
<td>1</td>
<td>Decrease current in steps of 5-10%</td>
</tr>
<tr>
<td></td>
<td>Insufficient Current/Energy</td>
<td>N/A</td>
<td>Increase current in steps of 5-10%</td>
</tr>
<tr>
<td></td>
<td>Excess Time</td>
<td>4</td>
<td>Decrease weld time in steps of 5-10% (N/A for CO2)</td>
</tr>
<tr>
<td></td>
<td>Insufficient Time</td>
<td>N/A</td>
<td>Increase weld time in steps of 5-10% (N/A for CO2)</td>
</tr>
<tr>
<td></td>
<td>Insufficient Squeeze Time</td>
<td>1</td>
<td>Increase squeeze time in steps of 5-10% (N/A for CO2)</td>
</tr>
<tr>
<td></td>
<td>Insufficient Hold Time</td>
<td>3</td>
<td>Increase hold time in steps of 5-10% (N/A for CO2)</td>
</tr>
<tr>
<td></td>
<td>Insufficient Upset</td>
<td>1</td>
<td>Increase upset time in steps of 5-10% (N/A for CO2)</td>
</tr>
</tbody>
</table>

**Power Supply Related:**
- Excess Force (N/A) Increase force in steps of 10-20%
- Insufficient Force (N/A) Increase force in steps of 10-20%
- Poor Weldhead Follow-up (N/A) Use weldhead with best follow-up and low mass electrode holders.
- Wrong Polarity (N/A) Reverse polarity of each electrode.

**Material Related:**
- Poor Projection Design (3) Contact Unitek Equipment Applications Lab for assistance.
- Poor Plating or Contaminated Parts (2) Clean parts before welding. Check plating thickness and cure.
- Incompatible Metals (N/A) Change one metal or use third interface metal.
- Requires Cover Gas (4) Use argon or similar cover gas.
- Parts Mispositioned (2) Properly position the parts to hold parts in place.

**Electrode Related:**
- Wrong Electrode Material (N/A) Check Electrode/Matrix Selection Chart.
- Electrode EX (1) Clean electrodes and/or parts to be welded.
- Electrode Tip Shape (2) Use constant area electrodes or shape to suit application.
- Misshaped Electrodes (N/A) Regular or reshape electrodes or increase cleaning schedule.

**Miyachi Unitek**

Spirit of Innovation.
Common Material and Process Problems:

Materials:
• Material Substitutions
• Plating Inconsistencies
• Varying Surface Roughness
• Oxidation
• Contamination
• Thickness Changes
• Projection Inconsistencies
• Poor Design

Process:
• Part Misplacement
• Varying Overlap
• Inconsistent Force
• Current Shunting
• Poor Electrode Condition
• Varying Gap
• Incorrect Electrode Material
• Weld Cable Problems
• Equipment Settings
Force and Timing Problems

Impact Force (variation)

Poor Follow-up (sparks)

Insufficient Force (sparks)

No Squeeze (sparks)

Squeeze

Heat

Hold

No Hold (variation)
Resistance Welding Diagram:

**EQUIPMENT**
- Part Positioning, Electrode Maintenance, etc.

**PROCESS**
- Composition, Plating, Hardness, Geometry, etc.

**MATERIALS**
- Power Supply, Weld Head, Electrodes, etc.

**WELDING SUCCESS**
- OPTIMIZED SETTINGS & MONITORING
- MATERIAL CONTROL
- EQUIPMENT SELECTION
Questions & Answers

Thank you for your time...