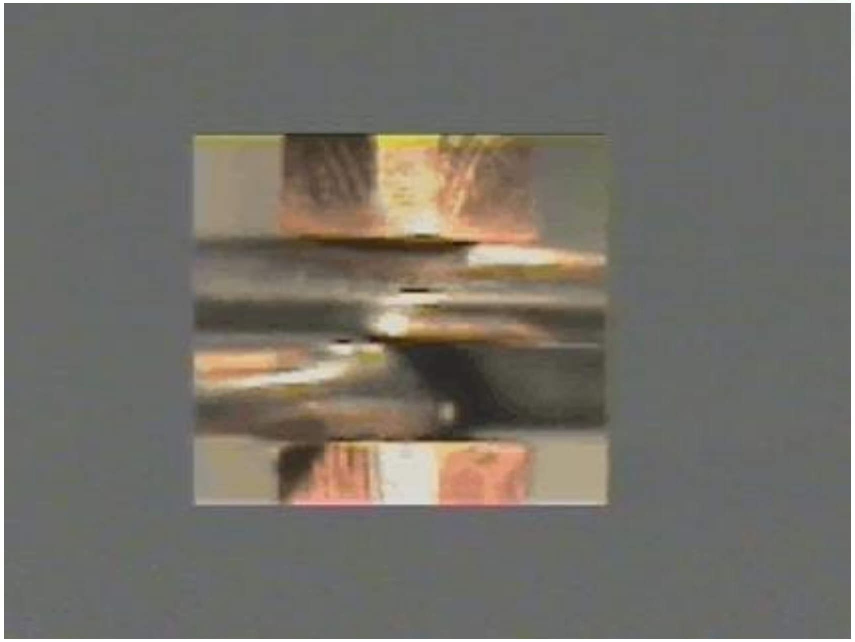
Resistance Welding Training



Welding Fundamentals

Spirit Of Innovation™
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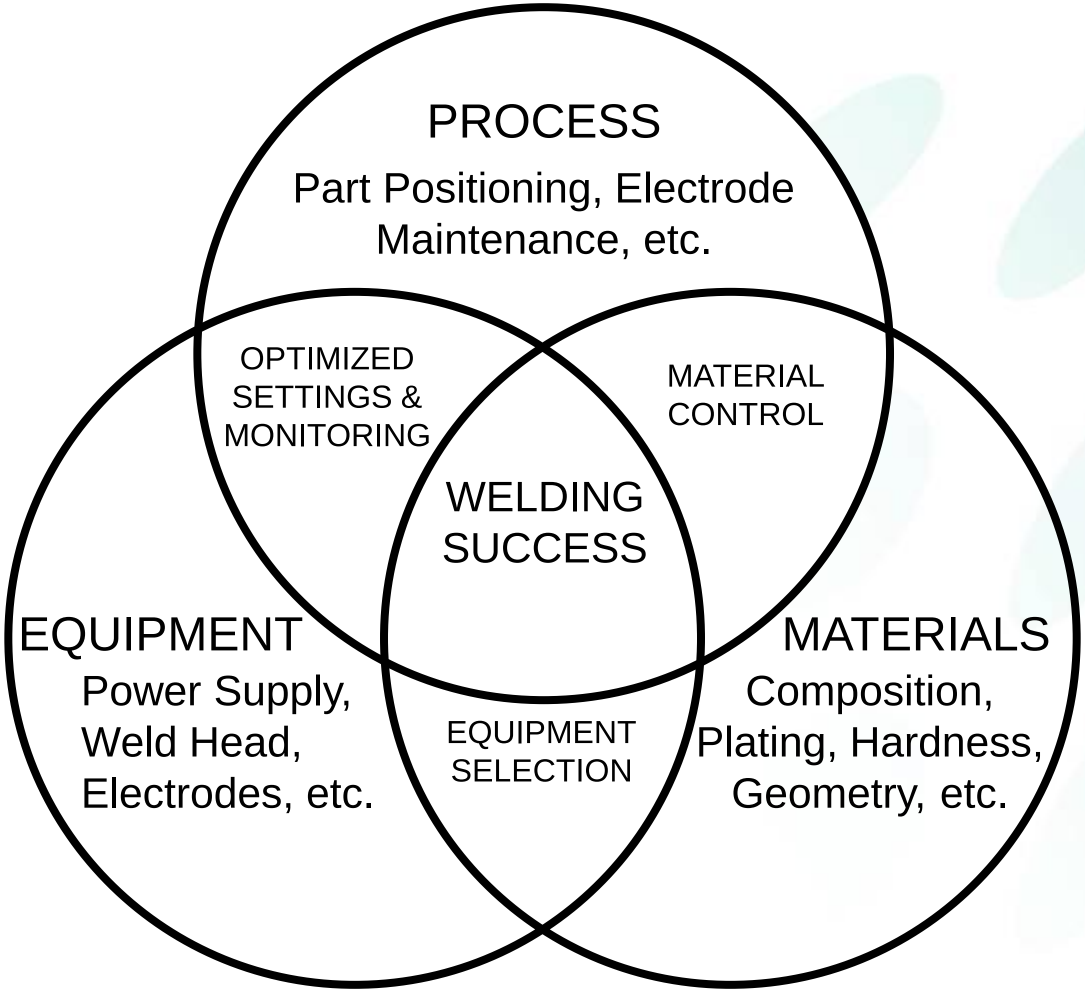
Resistance Welding Diagram:

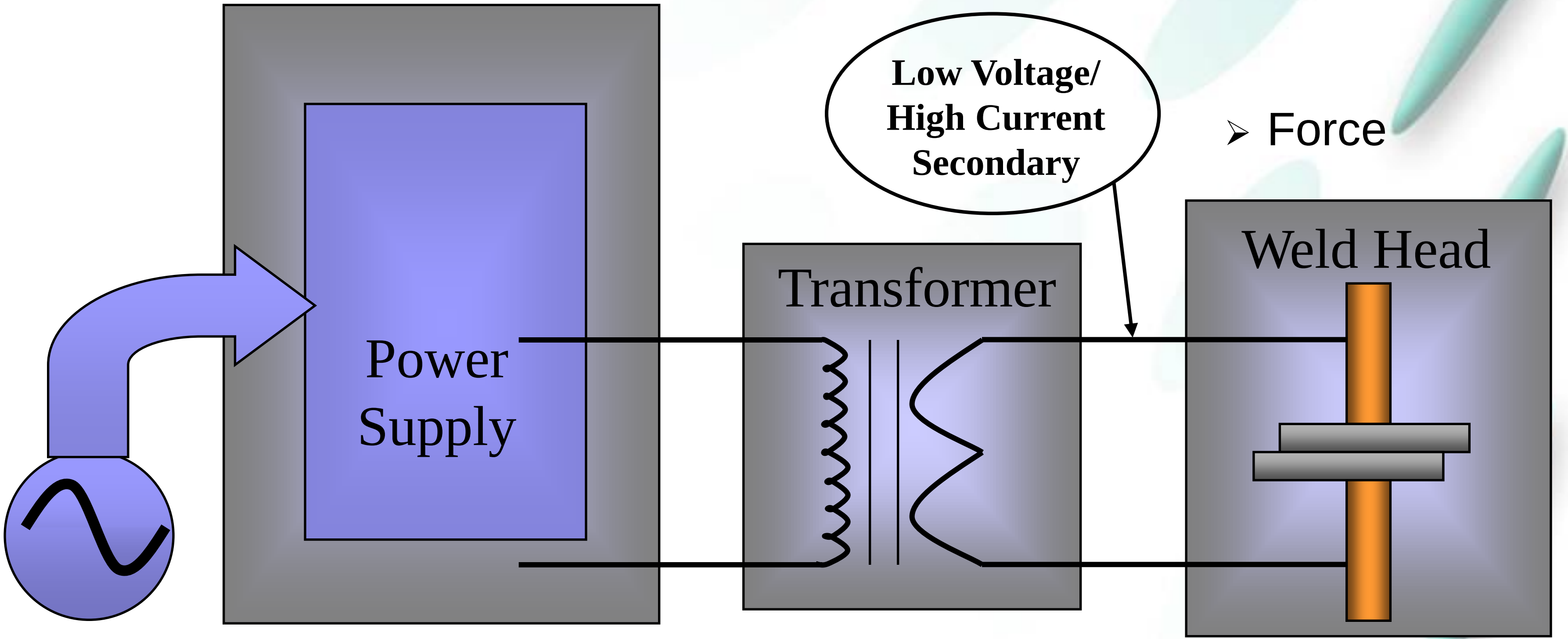


Let's Start With Some Definitions: How Does it Work?

- *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)*

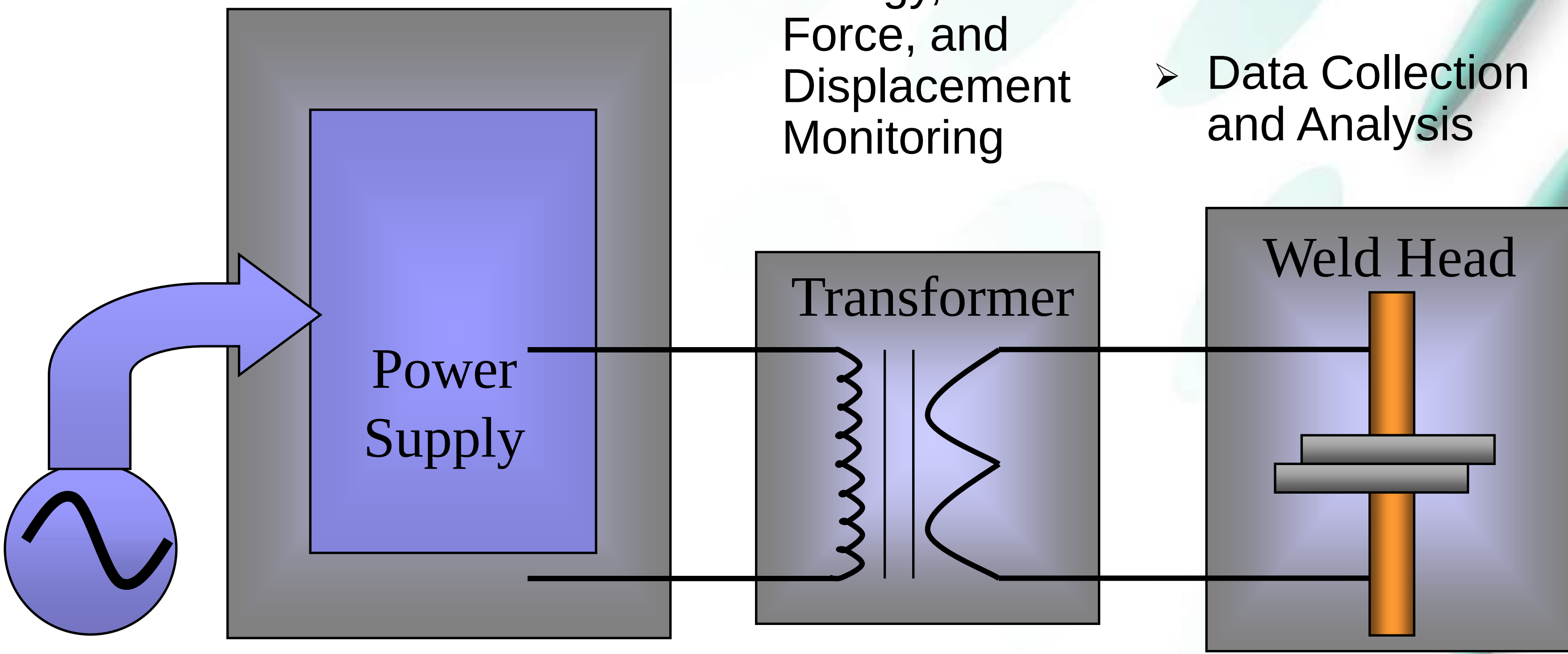
Definitions:
Basic Welding System

- Weld Current
- Time

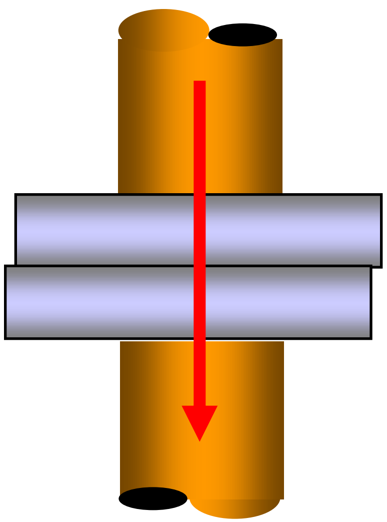


Definitions:
Advanced Welding Systems

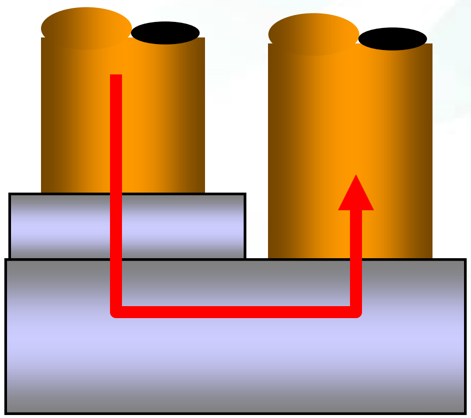
- *Closed Loop Control*
- Energy, Force, and Displacement Monitoring
- Data Collection and Analysis



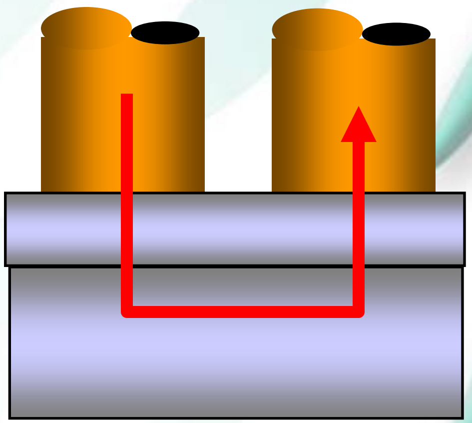
Definitions:
Electrode Configurations



Opposed
(Direct)

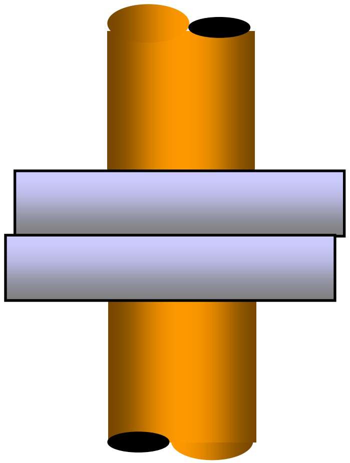


Step Weld
(Indirect)

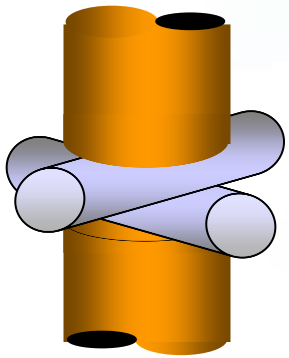


Series Weld
(Parallel Gap)

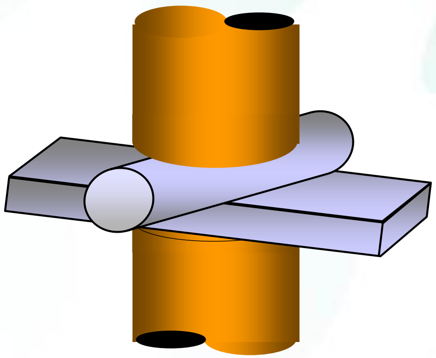
Common Part Geometries



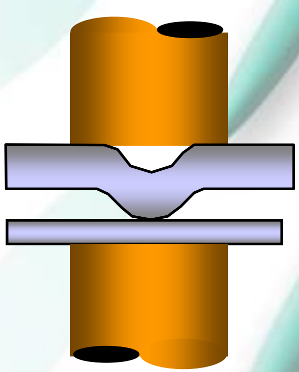
Flat



Round



Round /Flat

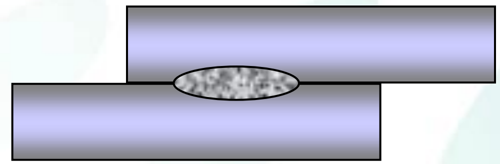


Projection

Types of Bonds

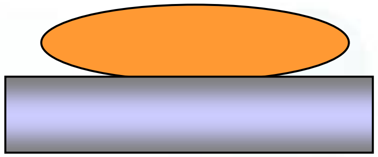
Fusion

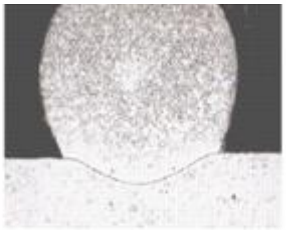
Both metals melt and mix.



Solid-State

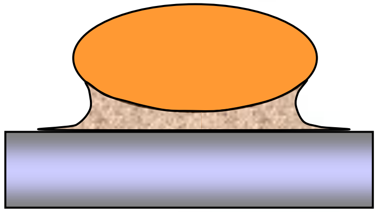
Bring temperature up to 70-80% of melting point.





Solder or Braze

(Solder <400C m.p. Filler)
(Braze >400 C m.p. Filler)
Note: Sil-phos is a common brazing material.



Fusion Weld Video:

Weld Heat Formula

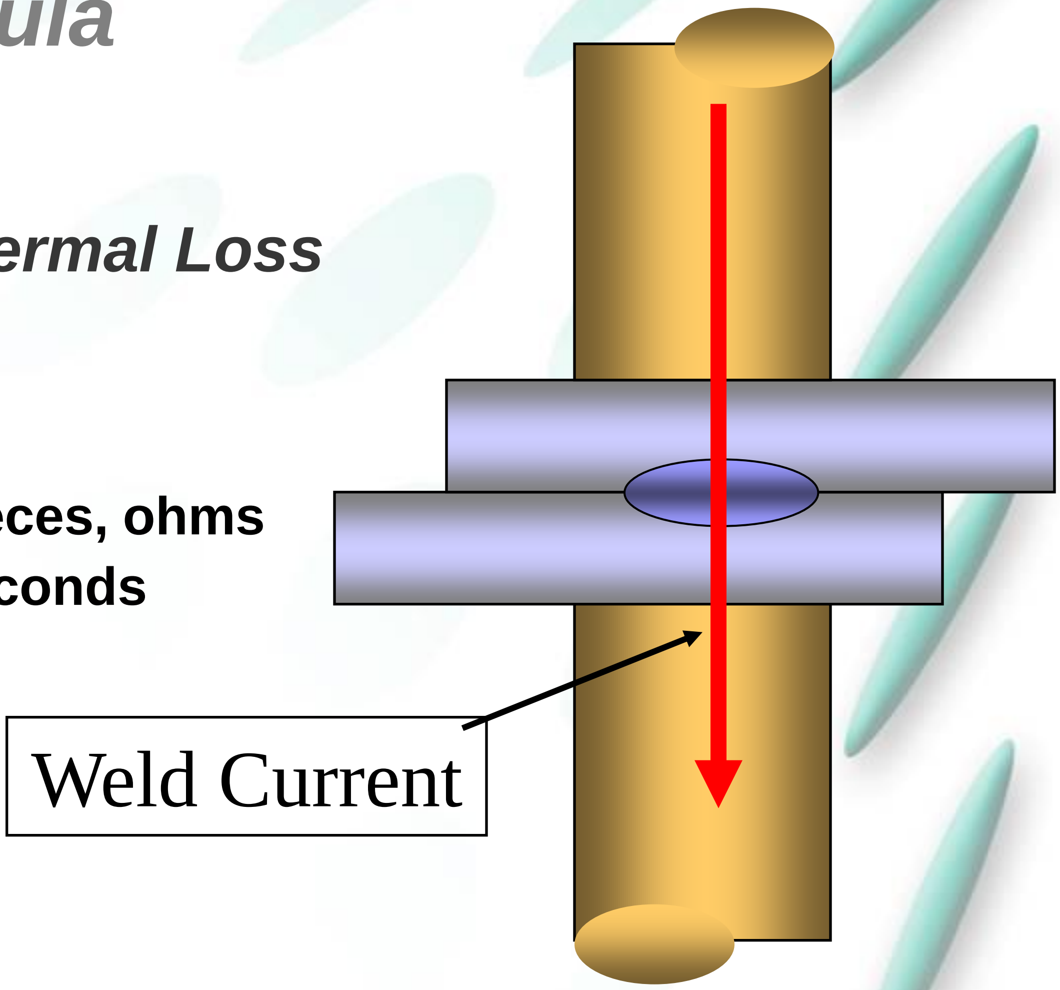
Weld Heat = I^2Rt – Thermal Loss

where:

I = weld current, amperes
R = resistance of work pieces, ohms
t = duration of current, seconds

Note:

Thermal Loss is the heat sinking into the parts, electrodes and tooling.



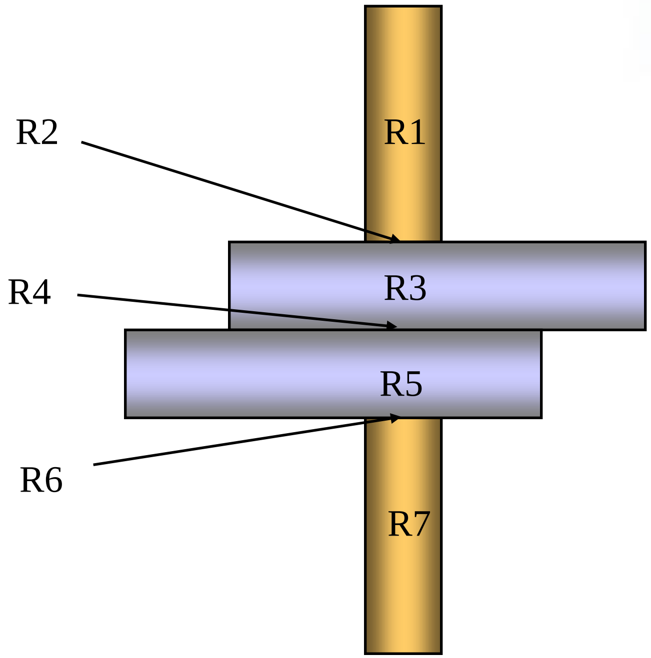
Weld Heat Formula for Different Feedback Modes:

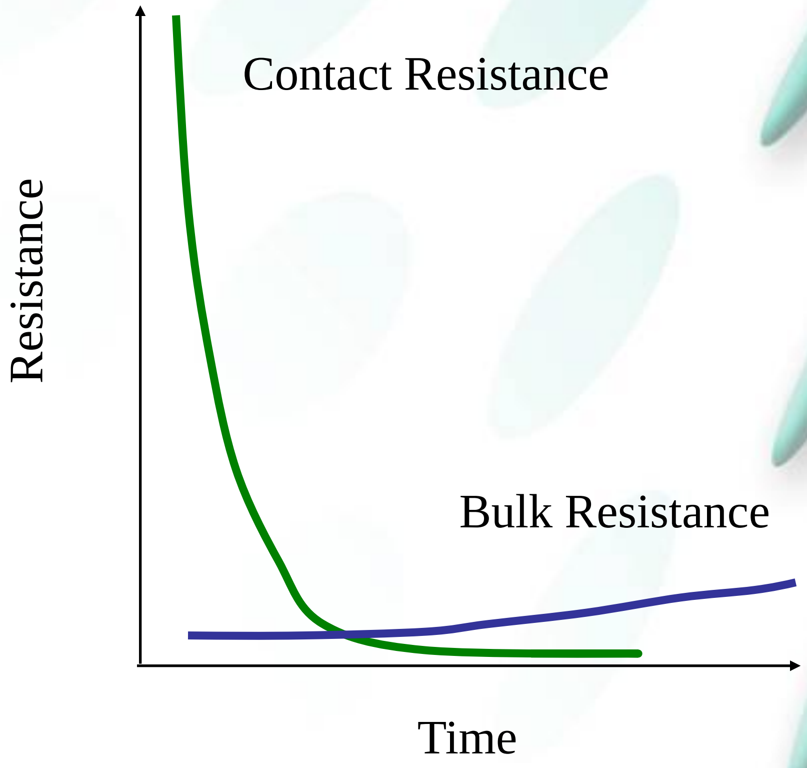
Weld Heat $= (I^2 \times R) \times t$ *– Thermal Loss*	***Current***
$= (V^2/R) \times t$ *– Thermal Loss*	***Voltage***
$= (I \times V) \times t$ *– Thermal Loss*	***Power***

= (Power) x t – Thermal Loss

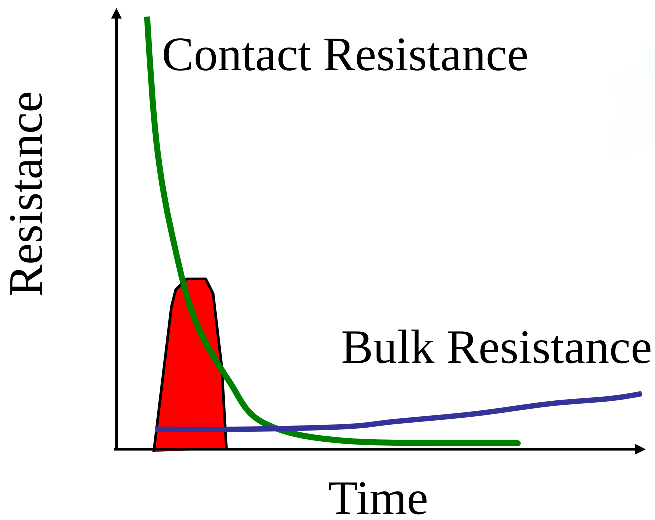
= Energy – Thermal Loss

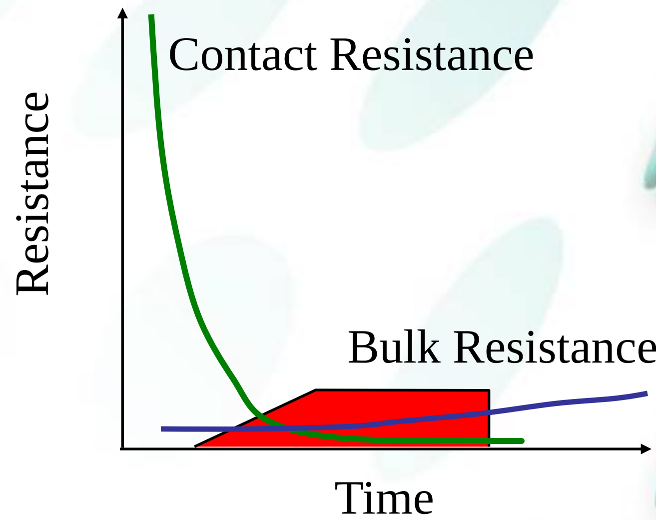
Contact and Bulk Resistance

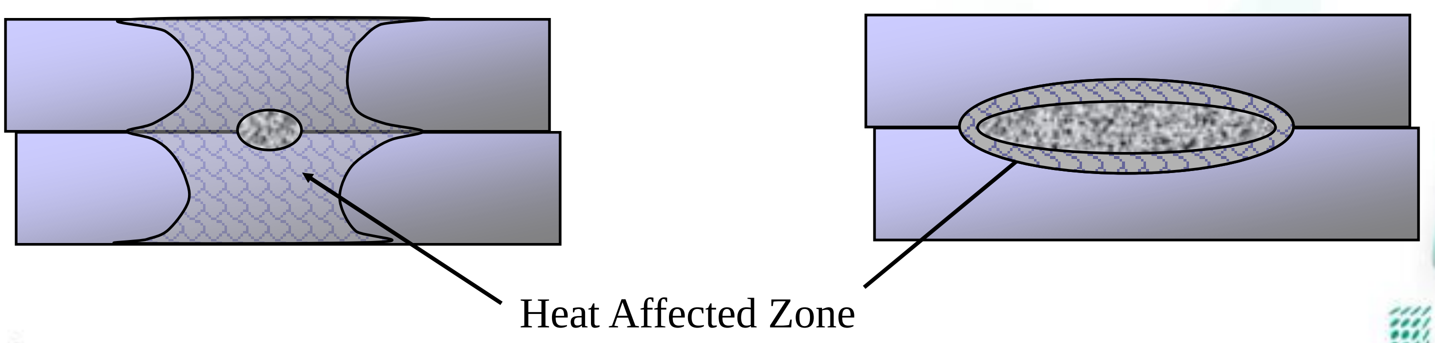




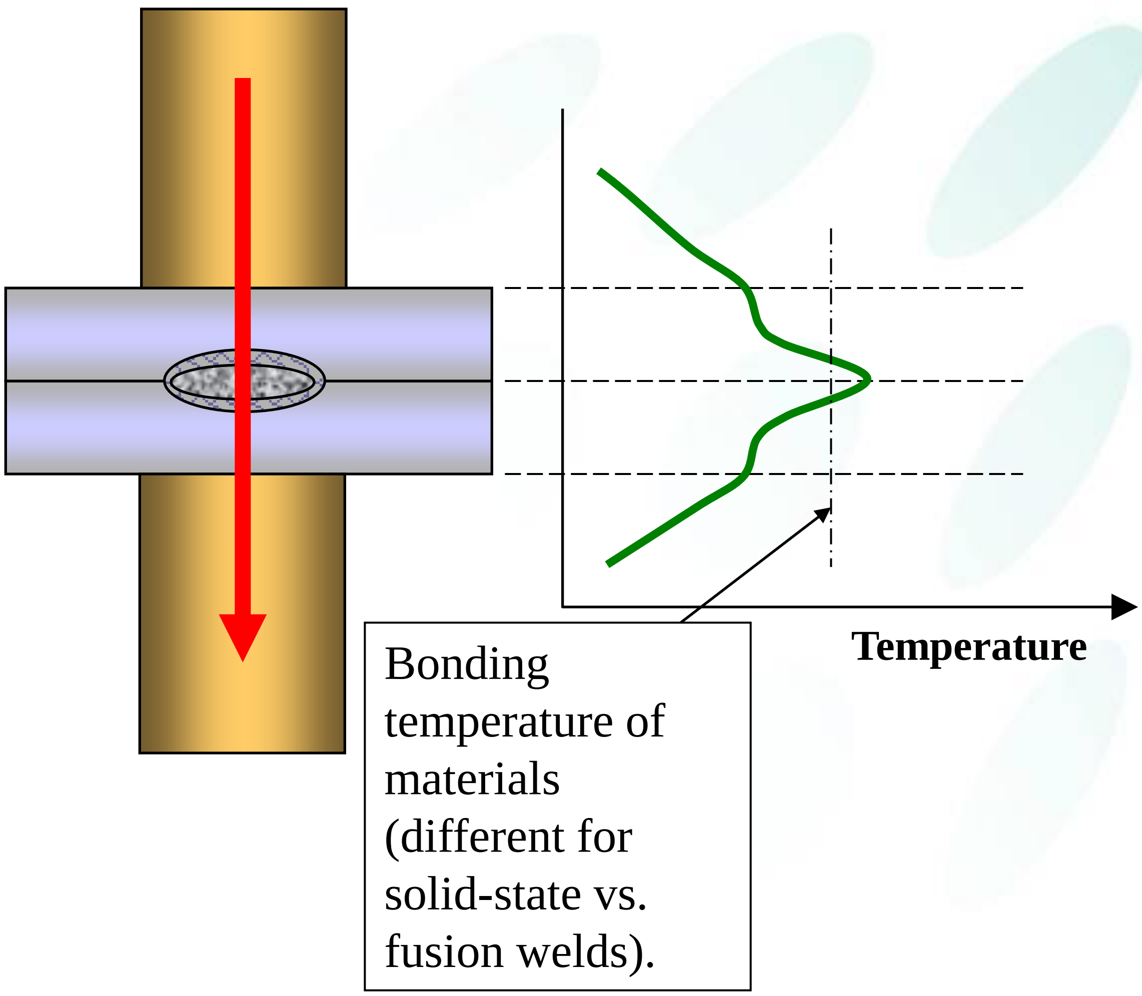
How Resistance Affects Heat Distribution



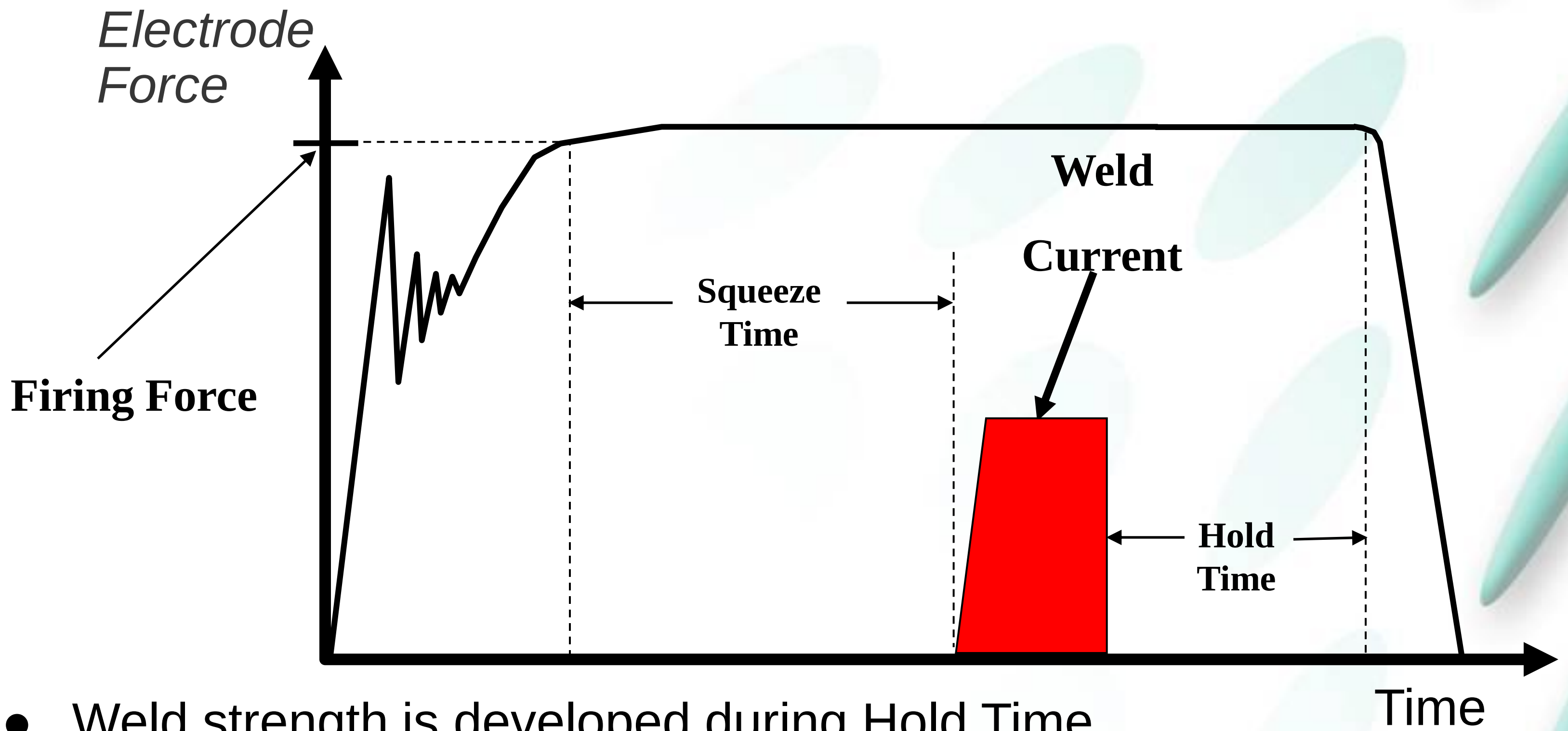




Heat Cross Section – Heat Balance

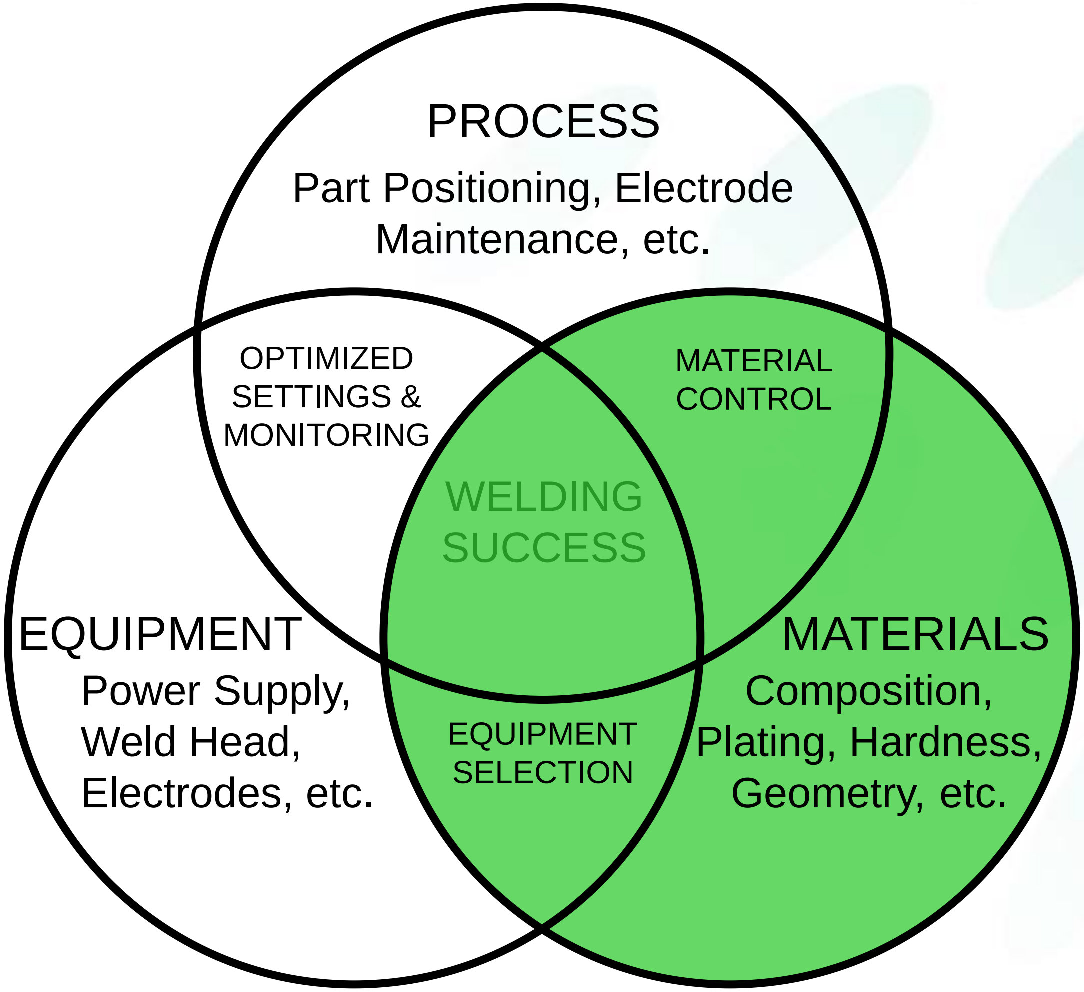


Basic Welding Schedule



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

Resistance Welding Diagram:



The first question - What are the materials?

- *Material Properties:*

  Electrical and thermal conductivity, melting point,

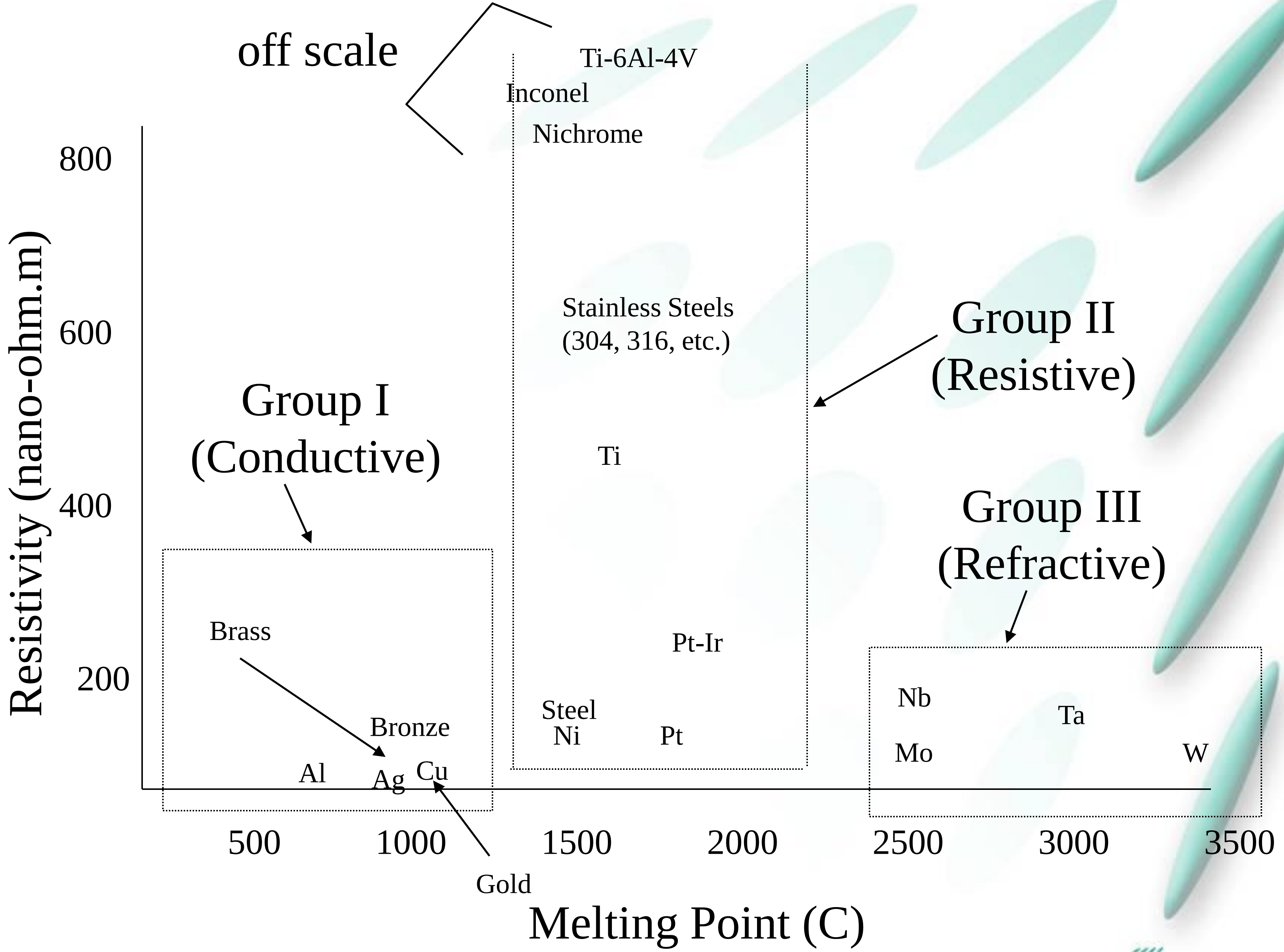
  hardness, and welding compatibility

- *Surface Conditions:*

  Plating, oxides, roughness, insulation, and contamination

- *Physical Part Design:*

  Size, shape, and access to welding area


off scale
Ti-6Al-4V
Inconel
Nichrome
800
600
400
200
Resistivity (nano-ohm.m)
Stainless Steels
(304, 316, etc.)
Group II
(Resistive)
Group I
(Conductive)
Ti
Group III
(Refractive)
Brass
Pt-Ir
Nb
Ta
Steel
Ni
Pt
Bronze
Mo
W
Al
Ag
Cu
500
1000
1500
2000
2500
3000
3500
Gold
Melting Point (C)

Dissimilar Materials

	Group I (Conductive)	Group II (Resistive)	Group III (Refractive)
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

Materials to be Welded (Melting Point °C)	Aluminum	Beryllium Copper	Brass	Cold Rolled Steel	Copper	Dumet	Galvanized Steel	Gold	Inconel, Kanthal, Kovar, and Nichrome	Molybdenum and Tungsten	MP35N	Nickel	Niobium	Phosphor Bronze	Platinum	Stainless Steel	Tita
Titanium (1670°)	5 A,E	4 A	4 A	2 A,B	4 E	3 A,B	3 A	4 A,E	1 A,B	2 A,B	2 A	2 A	2 A,B	5 A	2 A	2 A,B	1
	A,B c	A,B	A,B c	A,B a	A,B c	A,B d	A,B d	A,B d	A,B a	A e	A a	A,B	A,B	A,B c	A,B	A,B	A,B
Stainless Steel (1450°)	4 A,E	4 A	4 A	1 A,B	4 E	3 A,B	2 A	4 A,E	1 A,B	3 A,B	2 A,B	1 A	2 A,B	5 A	2 A,B	1 A,B	
	A,B c	A,B	A,B c	A,B a	A,B c	A,B d	A,B d	A,B d	A,B a	A,B e	A,B a	A,B a	A,B	A,B c	A,B	A,B a	
Platinum (1770°)	4 A,E	4 A	4 A	2 B	4 E	3 A,B	3 A	3 A,E	2 A,B	2 A	2 A,B	1 A	2 A,B	4 A	1 A		
	A,B	A,B	A,B	A,B	A,B c	A,B d	A,B d	A,B	A,B a	A b,e	A,B a	A,B a	A	A,B c	A a		
Phosphor Bronze (900°)	4 A,E	3 A	3 A	4 B	3 E	3 A,B	4 A	3 A,E	4 A,B	5 A,B	5 A,B	4 A	5 A,B	2 A			
	A c	A c	A c	A c	A c	A d	A d	A c	A c	A c,e	A c,d	A c	A c	A c			
Niobium (2470°)	4 A,E	4 A	4 A	3 B	4 E	3 A,B	3 A	4 A,E	2 A,B	2 A,B	2 A,B	3 A	2 A,B				
	A,B c	A,B c	A,B c	A,B	A,B c	A,B d	A,B d	A,B c	A,B a	A,B e	A,B a	A,B	A,B a				
Nickel (1450°)	4 A,E	3 A	3 A	2 B	3 E	2 A,B	2 A	3 A,E	1 A,B	2 A,B	2 A,B	1 A					
	A c	A	A	A a	A c	A d	A d	A	A a	A e	A a	A a					
MP35N (1400°)	4 A,E	4 A	4 A	3 B	4 E	3 A,B	3 A	4 A,E	2 A,B	2 A,B	1 A,B						
	A c	A c	A c	A	A c	A d	A d	A c	A a	A e	A a						
Molybdenum (2000°) & Tungsten (3400°)	4 A,E	4 A	4 A	4 B	4 E	4 A,B	4 A	4 A,E	3 A,B	2 A,B							
	A,B e	A,B e	A,B e	A,B e	A,B c,e	A,B d,e	A,B d,e	A,B e	A,B e	A,B b,e							
Inconel, Kanthal, Kovar, and Nichrome (1400° -1500°)	4 A,E	4 A	4 A	2 B	4 E	3 A,B	3 A	4 A,E	1 A,B								
	A,B c	A,B c	A,B c	A,B a	A,B c	A,B d	A,B d	A,B c	A,B a								
Gold (1060°)	4 A,E	2 A	2 A	4 B	2 E	3 A,B	4 A	2 A,E									
	A,E c	A,E a	A,E	A,E c	A,E c	A,E d	A,E d	A,E									
Galvanized Steel (1450°)	4 A,E	4 A	4 A	2 B	4 E	3 A,B	2 A										
	A c,d	A c	A c	A d	A c	A d	A d										
Dumet (N/A)	4 A,E	3 A	3 A	2 B	3 E	2 A,B											
	A,B d	A,B d	A,B d	A,B d	A,B d	A,B d											
Copper (1080°)	4 A,E	2 A	2 A	3 B	2 E												
	E c,d	E	E	E d	E												
Cold Rolled Steel (1450°)	4 A,E	4 A	4 A	1 B													
	B c,d	B	B	B a													
Brass (900°)	4 A,E	2 A	2 A														
	A c	A	A														
Beryllium Copper (980°)	4 A,E	2 A															
	A c,d	A															
Aluminum (660°)	3 A																
	A d																

Key:

Weldability	Electrode Material Choice
Electrode Material Choice	Comments

Designing Parts for Weldabil

- In general, resistive par conductive parts.
- Consider the melting po and thermal conductivit
- Balance the thermal ma
- If the thermal imbalanc the part with the greate conductive part.
- Design parts for easy el electrode configuration

Weldability Codes:

1	Excellent
2	Good
3	Fair
4	Difficult
5	Very Difficult

Electrode Materials:

Code	Description and Applications
A -	Glidcop - 0.15% Al Oxide Dispersion Strengthened Copper. Long life, high strength electrodes primarily for welding resistive parts.
B -	RWMA2 - Copper Chromium Alloy. Used for welding steels, nickel alloys, and other resistive parts.
C -	RWMA3 - Copper Cobalt Beryllium Alloy. Used for welding resistive 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 -	RWMA14 - Molybdenum. Usually inserted into RWMA2 shank. Used for welding copper, silver, gold, and their alloys.

Comments:

a -	High joint possible.
b -	Use powe closed lo
c -	Low joint possible.
d -	Electrode occur.
e -	Short wel necessary

Electrode Materials

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

RWMA: Resistance Welder Manufacturers' Association
IACS: International Annealed Copper Standard

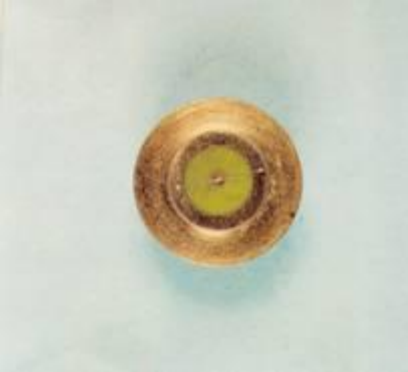
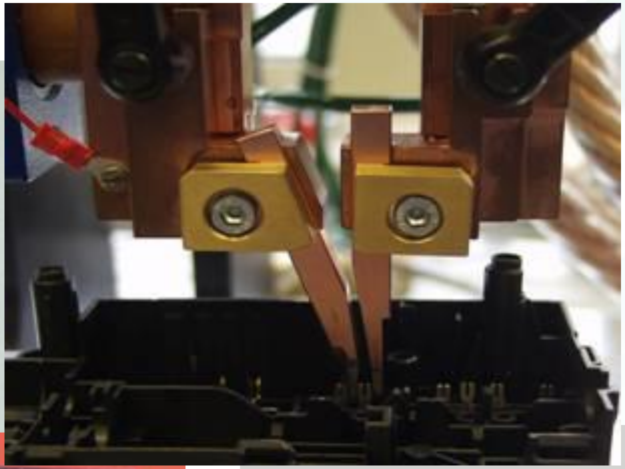
Part Surface Conditions

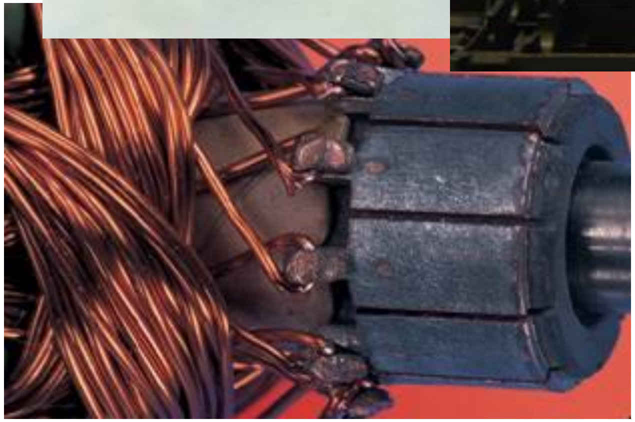
- Plating Inconsistencies
- Surface Roughness
- Oxidation
- Contamination

Surface conditions must be addressed prior to or during welding.

Design for Weldability

Consider part size, shape, and access to the welding area

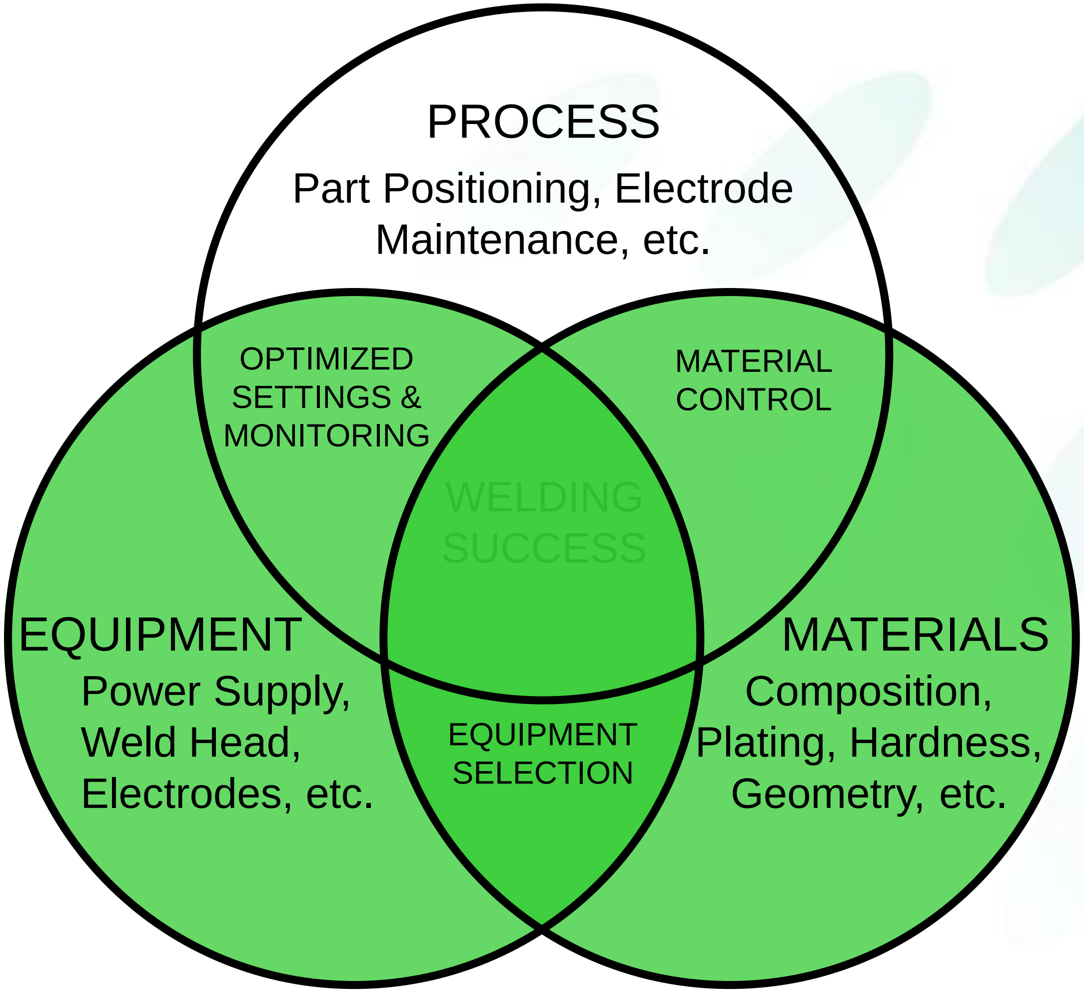





Use of Weld Projections

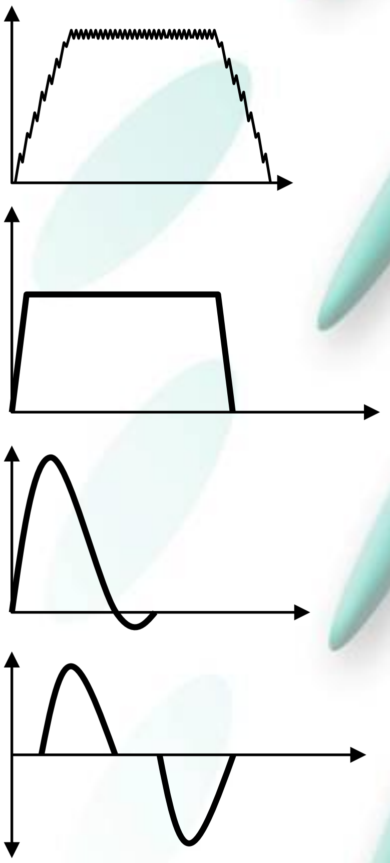
- Promotes Heat Balance:
  - ✓ Reduces thermal mass of thicker piece
  - ✓ Increases current density
  - ✓ Increases part interface resistance
- Extends Electrode Life:
  - ✓ Larger electrode face can be used
- Ensures Current Path:
  - ✓ Minimizes effects of shunting

Resistance Welding Diagram:

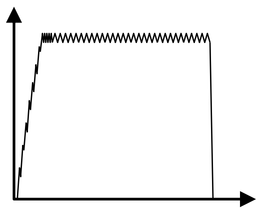


Power Supply Technologies:

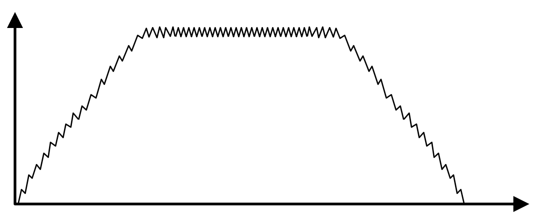
- *High Frequency Inverter (HF)*
- *Linear DC*
- *Capacitor Discharge (CD) "Stored Energy"*
- *Direct Energy (A.C.)*



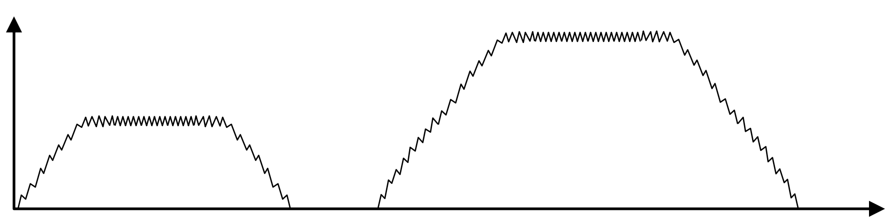
High Frequency (HF) Attributes



Single Pulse



Upslope/Downslope



Dual Pulse

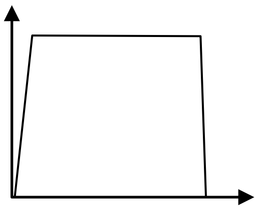
Characteristics:

- **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**

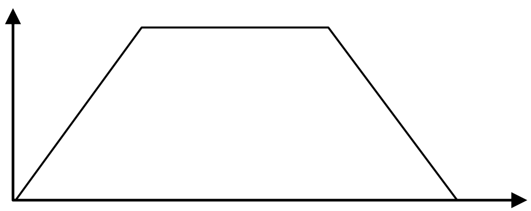
Applications and Use:

Best control for automation. Extends electrode life. Can weld a wide range of applications.

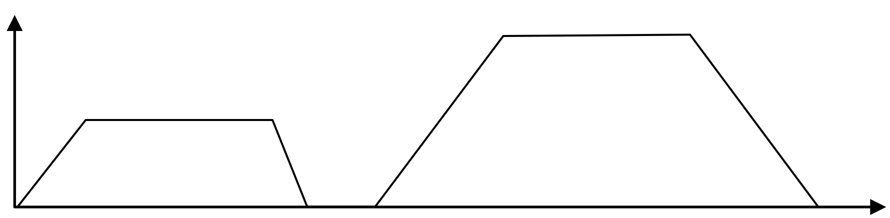
Linear DC Attributes



Single Pulse



Upslope/Downslope



Dual Pulse

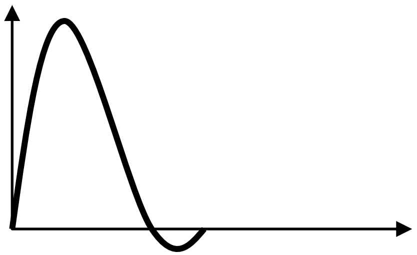
<u>Characteristics</u>:

- **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**

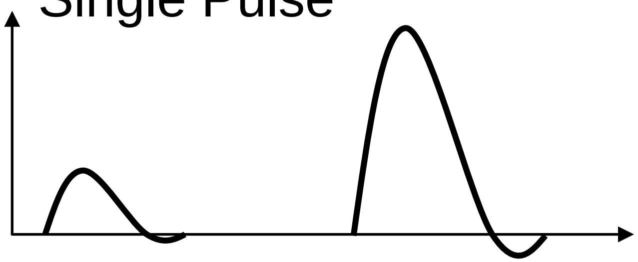
<u>Applications and Use</u>:

Ultra stable waveform. Extends electrode life. Best choice for welding fine wires and thin foils.

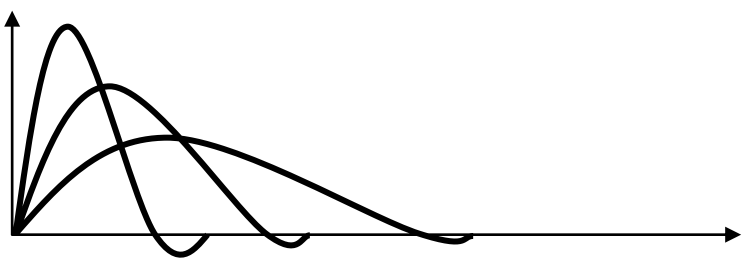
Capacitor Discharge (CD) Attributes



Single Pulse



Dual Pulse



Pulse Width Adjustment

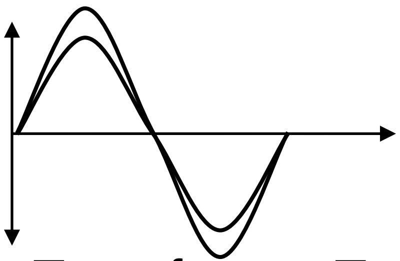
Characteristics:

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

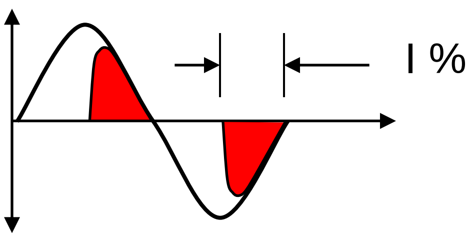
Applications and Use:

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

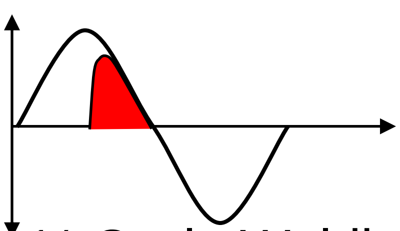
Direct Energy (A.C.) Attributes



Transformer Taps



% Current Control



½ Cycle Welding

<u>Characteristics</u>:

- **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**

<u>Applications and Use</u>:

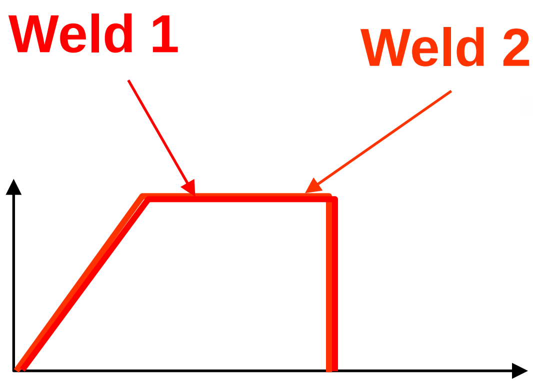
General purpose, lower cost welders with high energy output. Longer weld times useful for brazing applications.

Advantages of Closed Loop

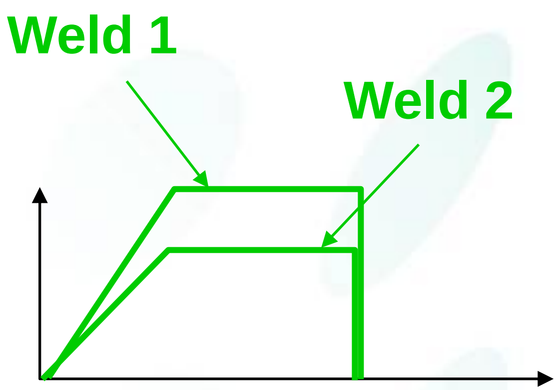
- Repeatable Output
- Upslope Control
- Longer Electrode Life
- Feedback Modes
- Built In Monitoring
- Process Tools
- Displacement and Force Monitoring (HF27)
- SPC

Repeatable Output

- 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.



Constant Current Weld Pulses

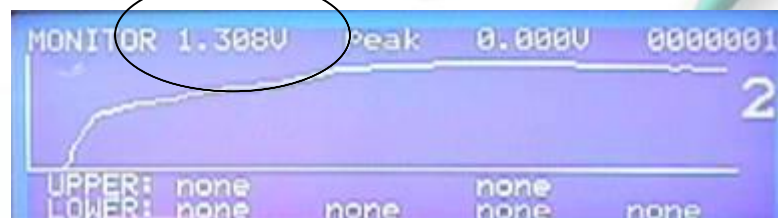


Monitored Output Voltage

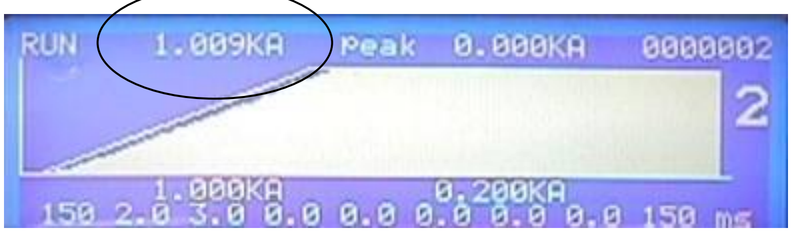
Repeatable Output

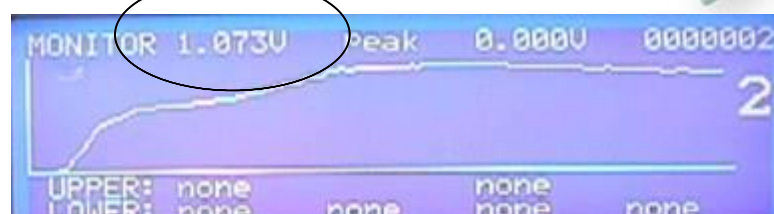
The same current is delivered, but the voltage adapts to the difference in work piece resistance.

Weld 1:

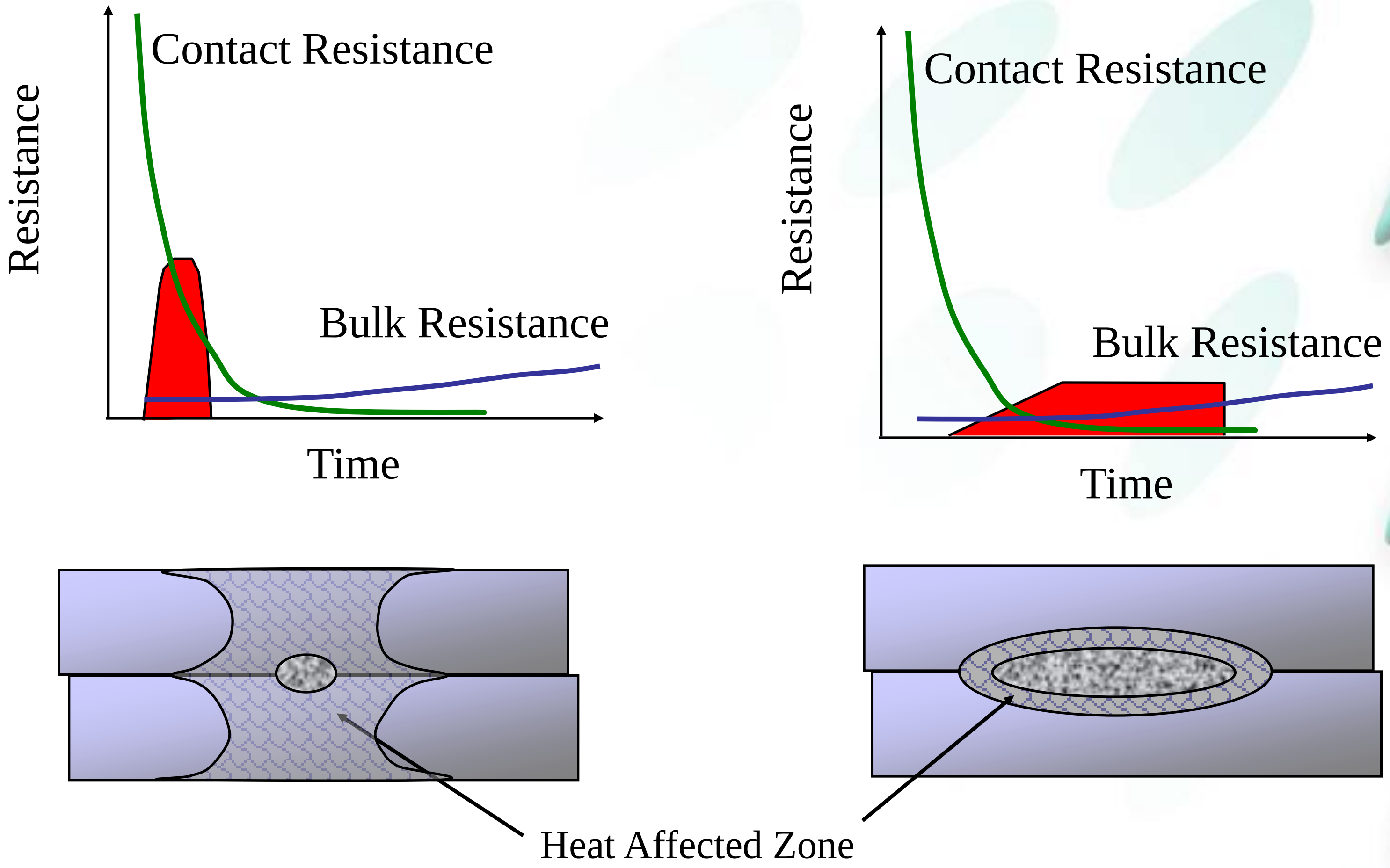


Weld 2:



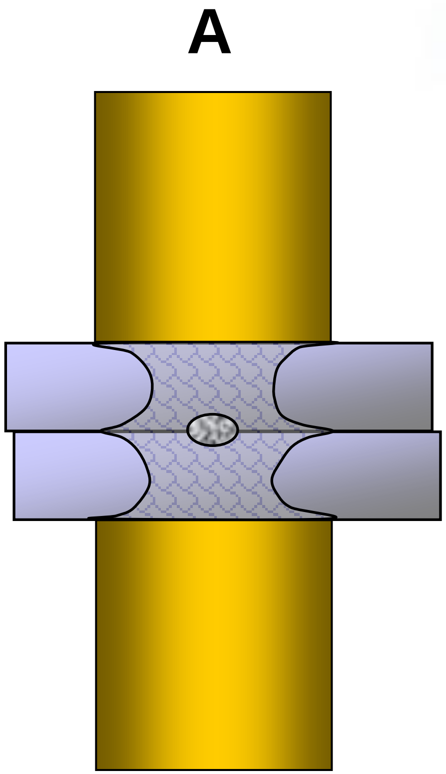


Upslope Control



Longer Electrode Life

- Which set of electrodes will last longer?
- Why?



Feedback Modes

Constant Voltage:

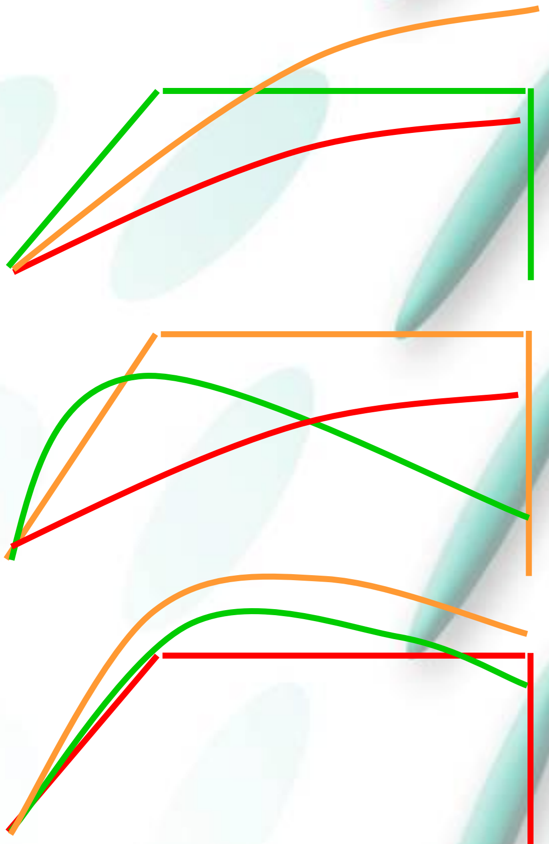
- Compensates for parts misplacement and force problems
- Reduces weld splash
- Ideal for projection welds
- **Monitor current**

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:

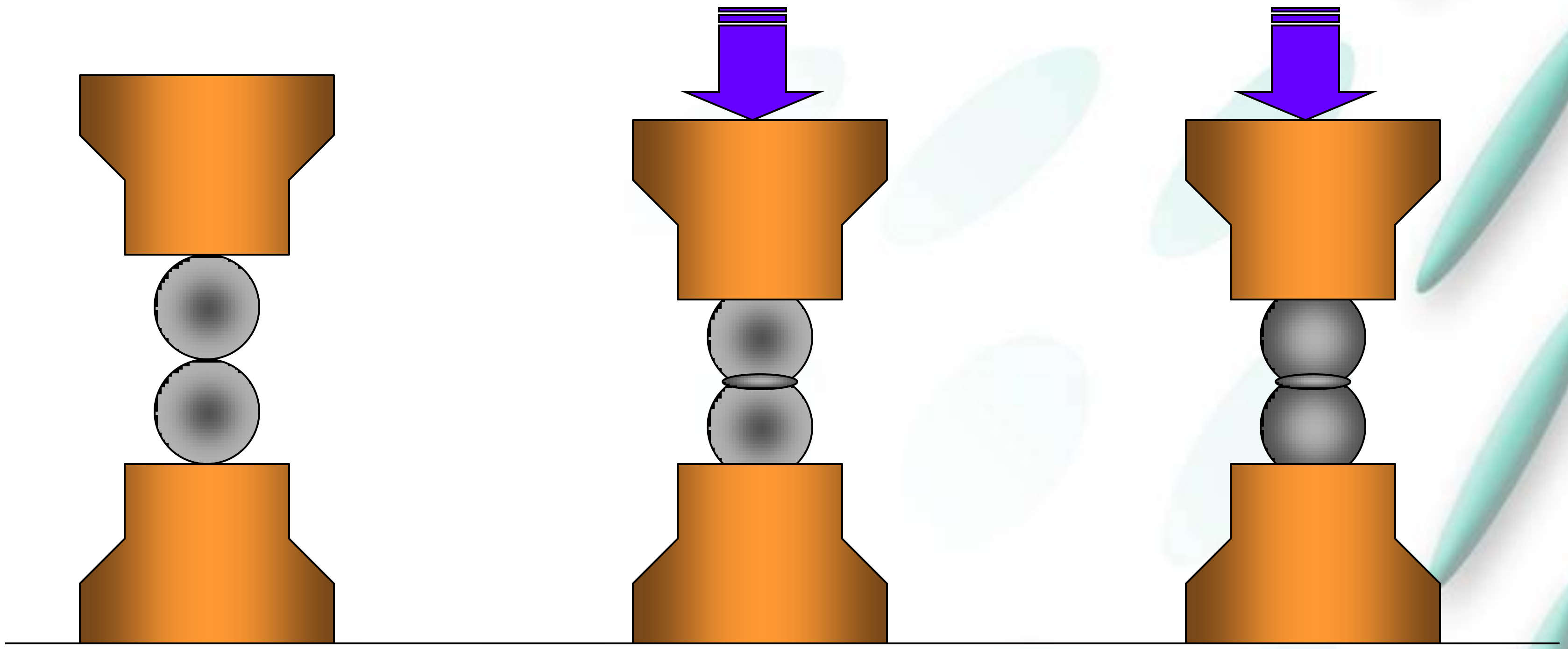
- Delivers same current regardless of resistance changes
- Compensates for part thickness changes
- Welding flat parts with consistent electrode to part fit-up
- **Monitor voltage**



Feedback Modes

Feedback Mode	Part Challenges	Process Challenges
Constant Voltage	Projections	Part Misplacement Varying Overlap Inconsistent Force Mushroomed Electrodes
Constant Power	Surface Roughness Plating Inconsistencies Oxidized Parts Contamination	Oxidized Electrodes Automated Systems
Constant Current	Stacked Flat Parts, Thickness Inconsistencies	Weld Cable Problems

Wire Weld



Beginning of Weld High Contact Resistance

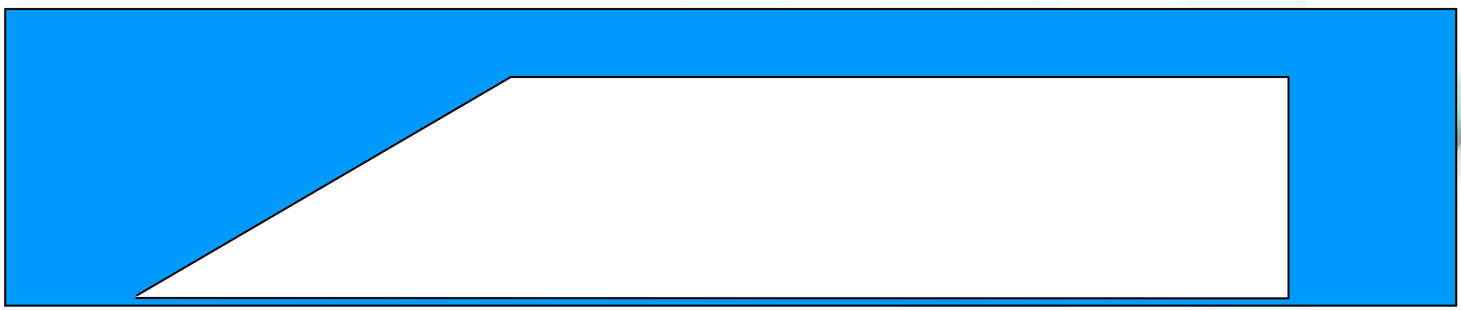
Wires Deform Reduced Contact Resistance

Parts Melt Severe Resistance Drop

Wire Weld

Use Constant Current with Upslope:

<u>Upslope</u> addresses the high contact resistance in the beginning of the weld. <u>Constant Current</u> addresses the severe resistance drop in the end of the weld.



Upslope **Constant Current (kA)**

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

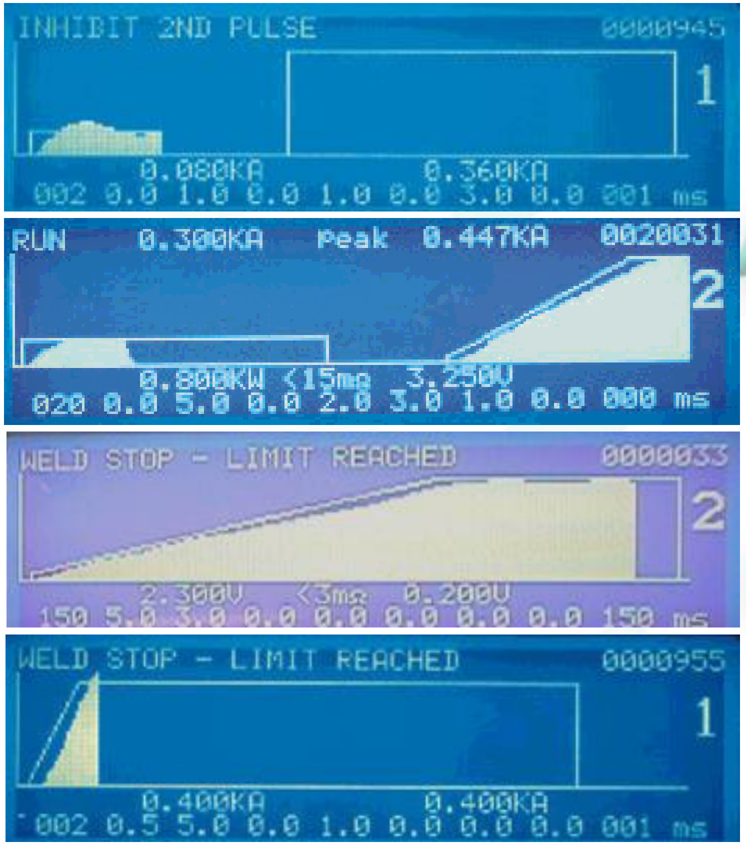
Process Tools

Pre Weld Check

Active Part Conditioner / Resistance Set

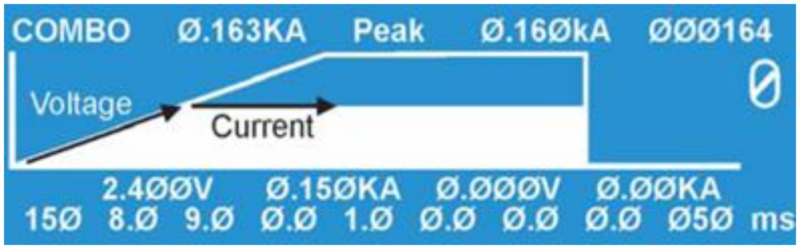
Weld to a Limit

Weld Stop



Advanced Process Tools (HF27)

Combo Mode:

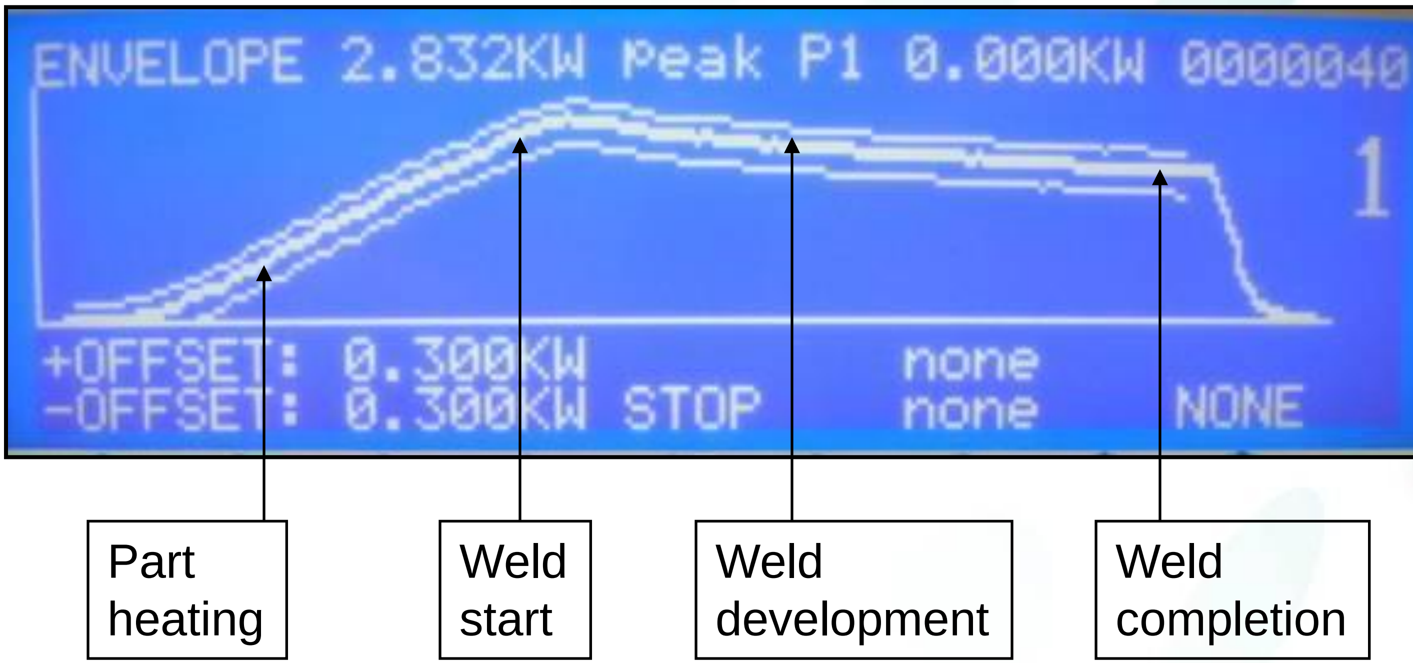


Energy Monitor:

Time Limits:

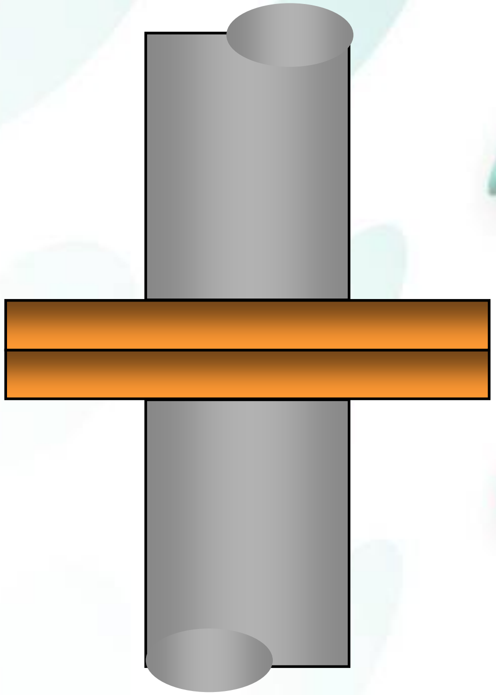
Envelope Limits (HF27)

Defining a complete weld signature:



Displacement Monitoring (HF27)

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

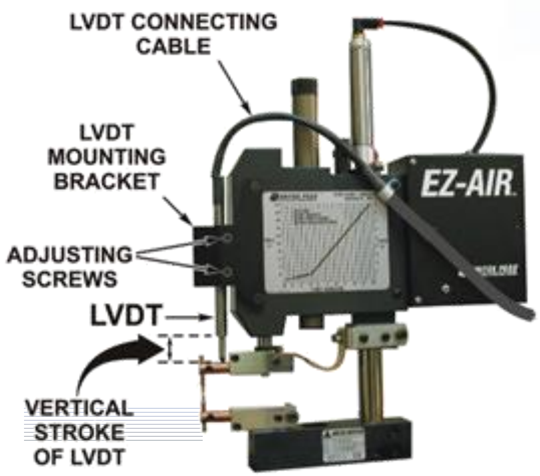


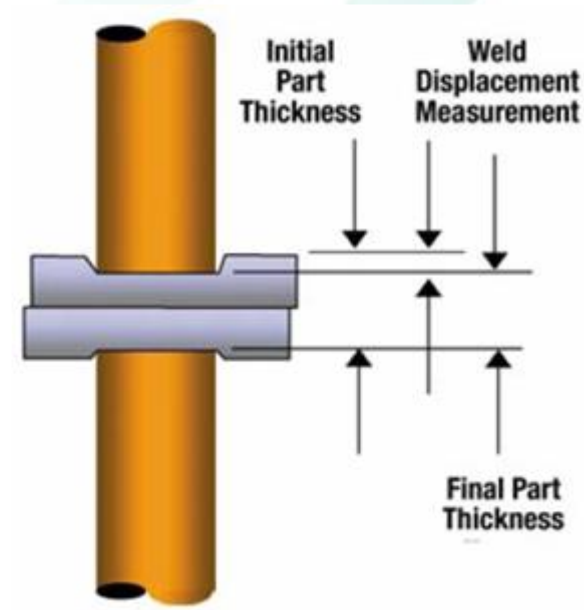
- *Ideal for Conductive Parts:*

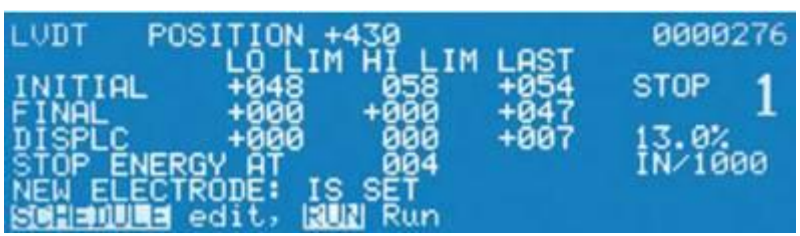
  When welding conductive parts, the bulk resistance of the electrodes is typically much greater than the resistance of the parts, so monitoring the electrical changes may be difficult. Displacement monitoring is preferred.

Displacement Monitoring (HF27)

Comprehensive process monitoring combines the mechanical and electrical characteristics of the weld.







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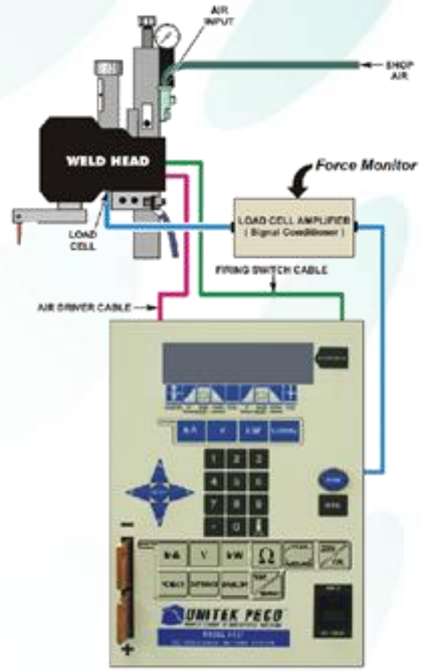
Force Monitoring (HF27)

Force can be monitored using a Load Cell:



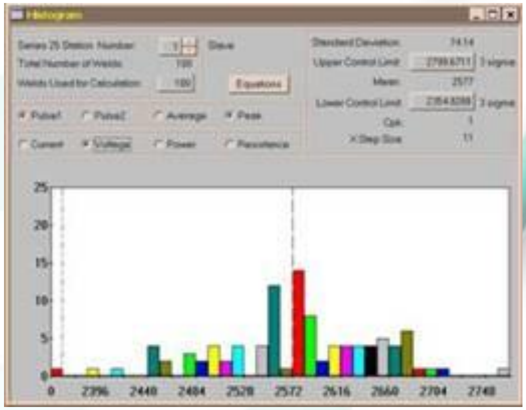
Multiple Relay Outputs

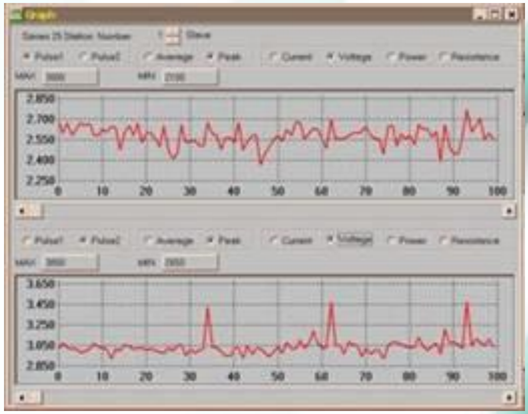
External Monitoring:

MG3 Process Sentry:

Statistical Process Control

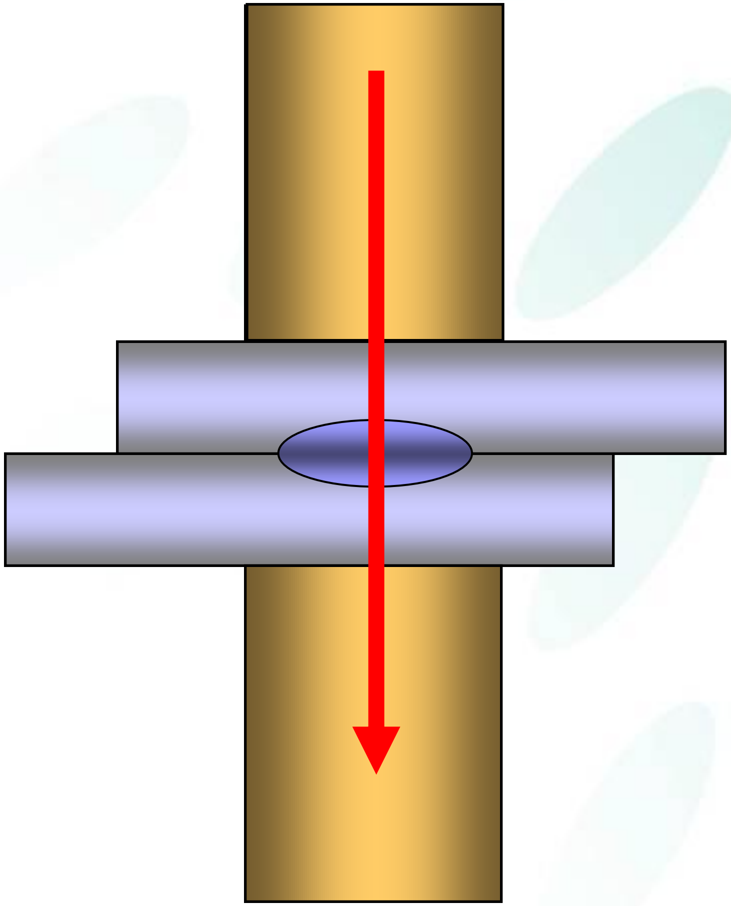
- *RS-232 or RS-485 transmission of weld data to a P.C.*
  - Identify Process Trends
  - Record Keeping
  - Quality Reporting
- S.P.C. software packages can generate control charts and provide data summaries





Weld Head Actions:

- ❑ Approach
- ❑ Impact
- ❑ Squeeze
- ❑ Fire
- ❑ Follow-up
- ❑ Hold



Weld Head Video:

Follow-up Force:

Video Loading…

Weld Head Video:

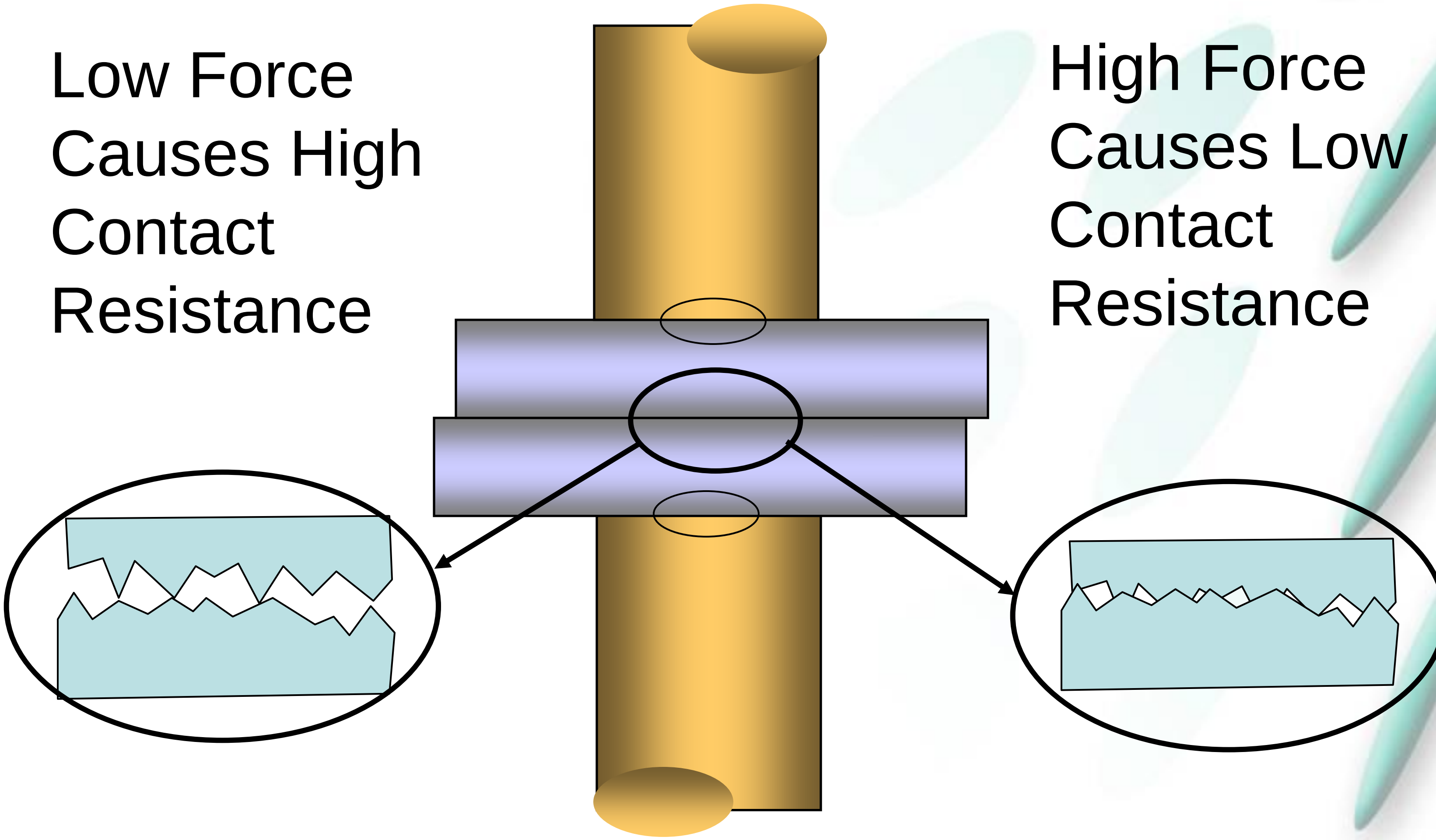
Insufficient Follow-up Force:

Video Loading…

How Electrode Force Affects Contact Resistance:

Low Force Causes High Contact Resistance

High Force Causes Low Contact Resistance

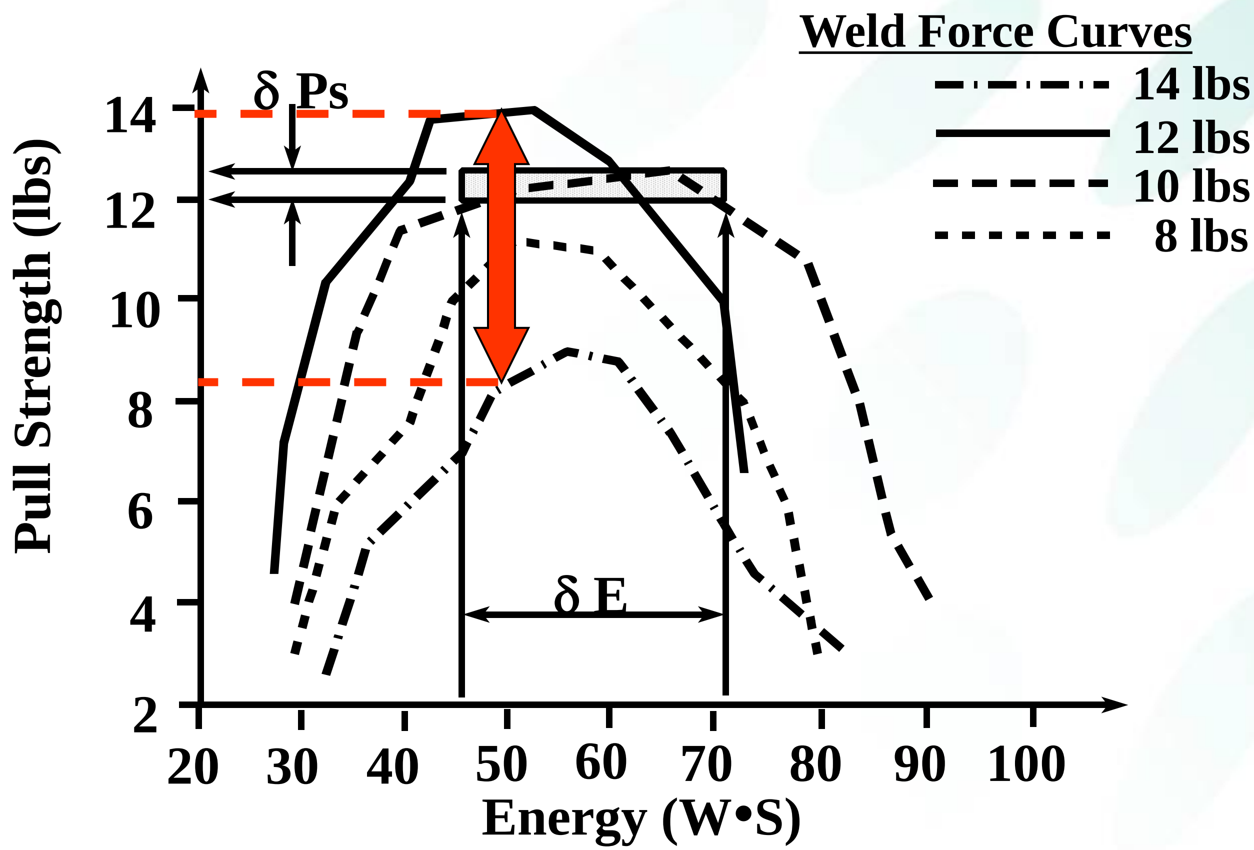


Poor Force Control Results in:

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

Weld Strength Profile:

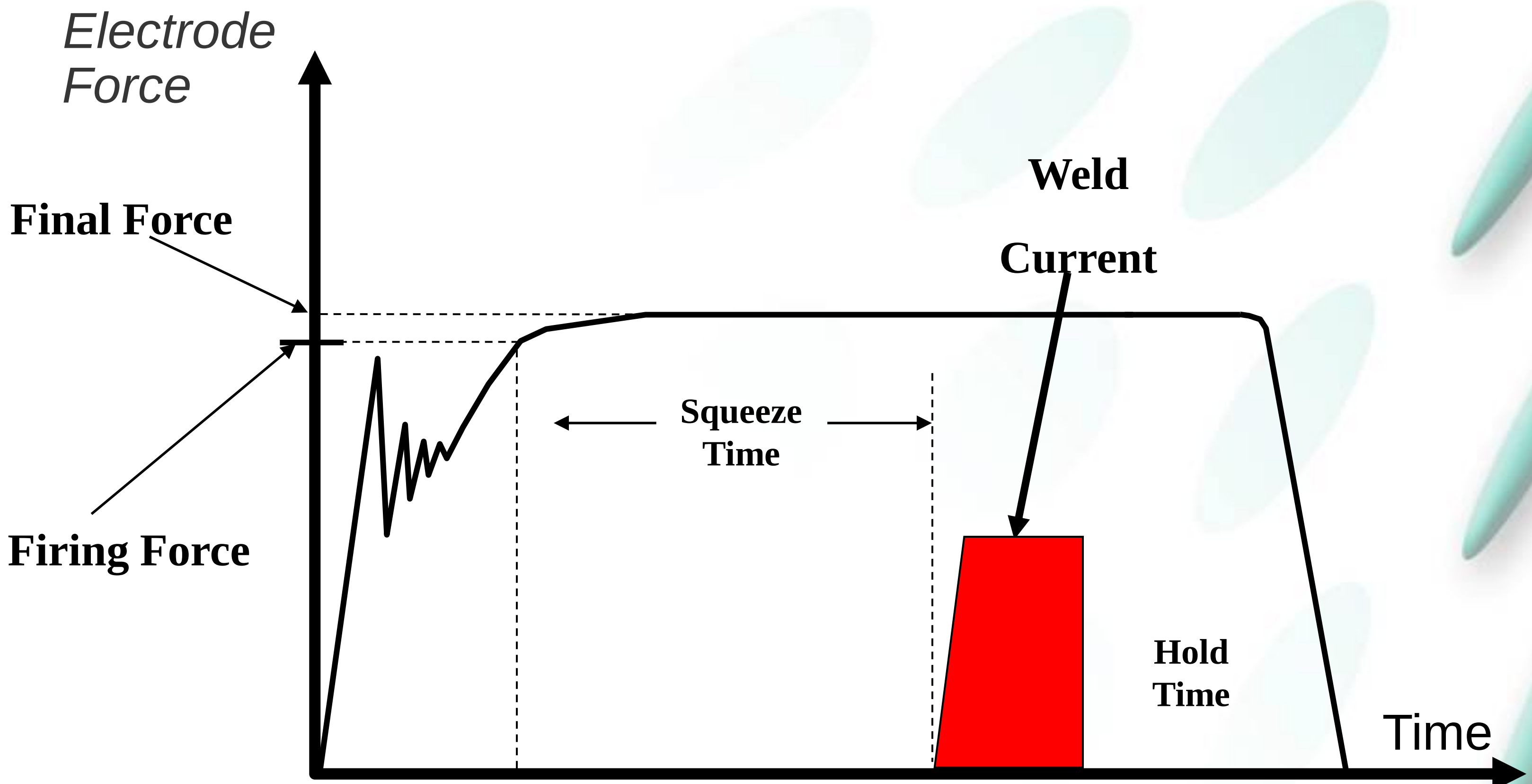
Weld .032 dia. copper/tin wire to .010x.031 nickel ribbon



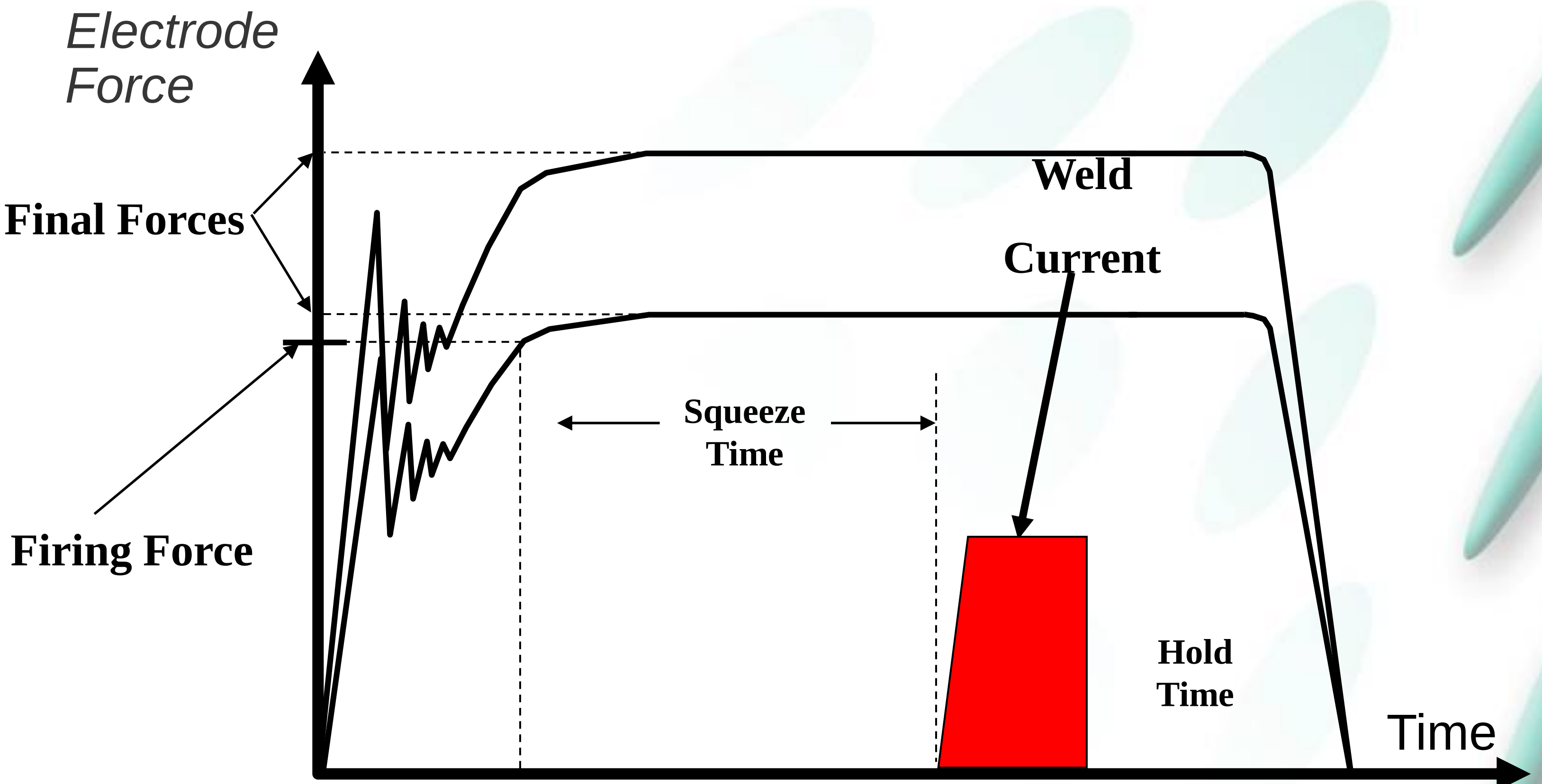
Weld Head Actuation Methods:

- Manual
  - Foot Pedal & Coil Spring
- Pneumatic
  - Direct Air
  - Coil Spring
  - Proportional Pressure Control
  - EZ-AIR
- Cam Driven
  - Automation
- Servo Motor
- Electro Magnetic

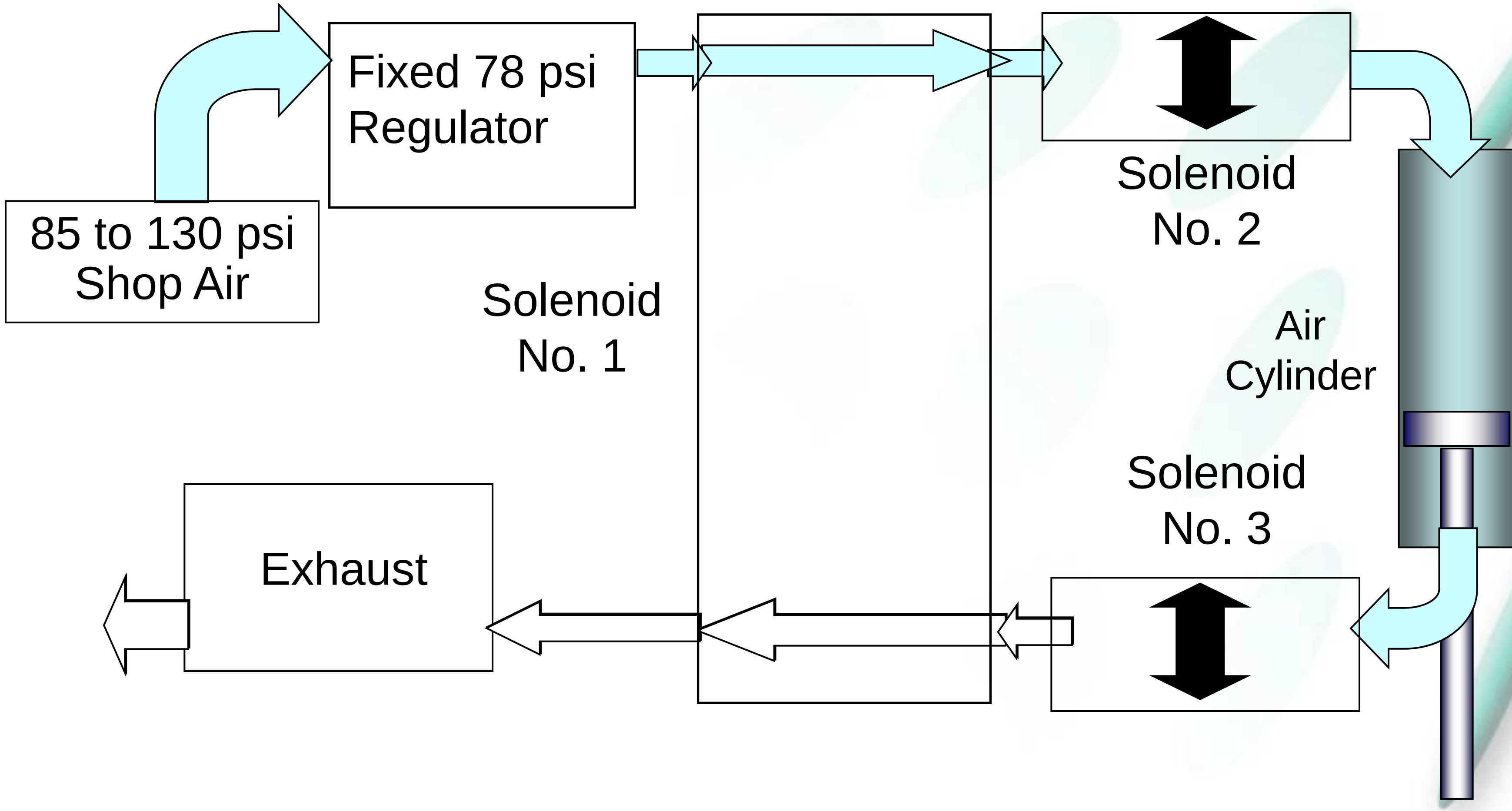
Electrode Force vs. Time for Force Fired Weld Head



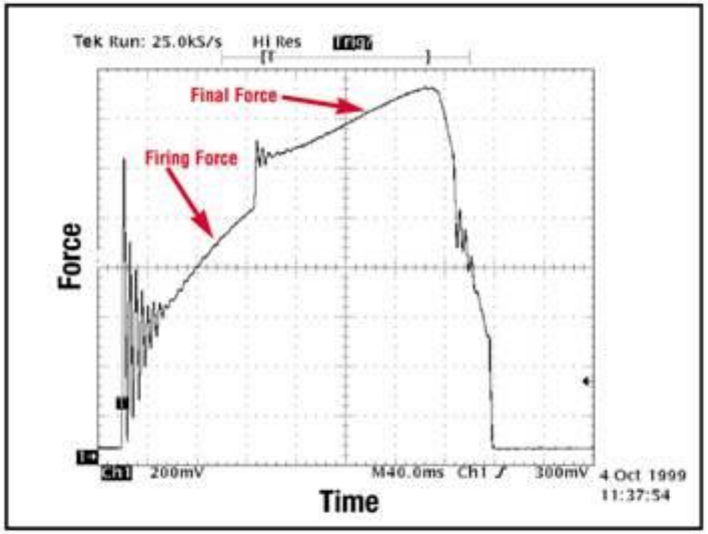
Electrode Force vs. Time for Two Different Operators

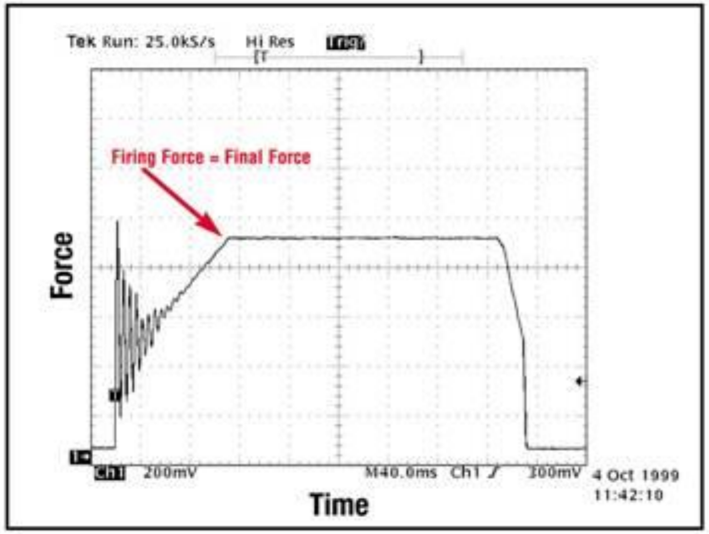


EZ-AIR™ Overforce Protection:



Electrode Force vs. Time Before and After EZ-AIR:





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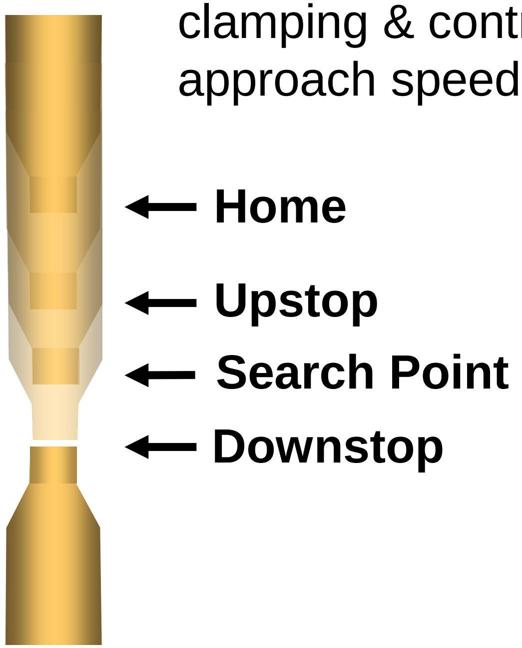
Motorized Weld Heads

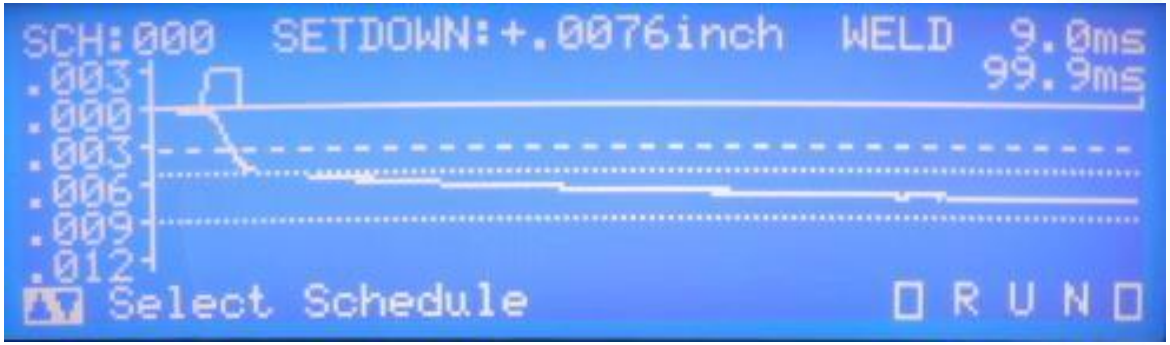
Program positions & speed for soft touch part clamping & controlled approach speed



Electro-magnetic Weld Heads

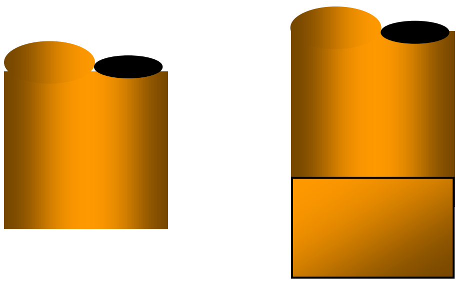
Programming Screen:

Weld to Displacement/Set Limits:

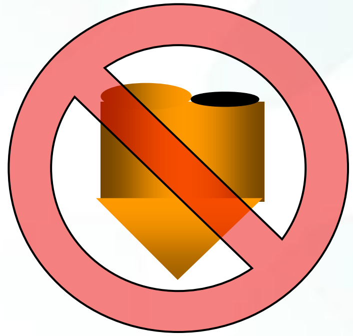


Electrode Design

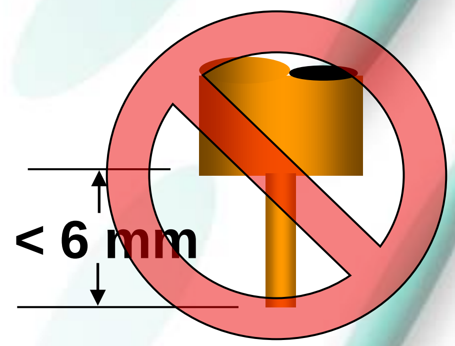
Use constant area tip design



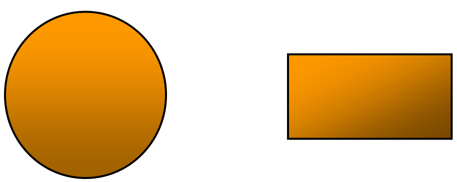
Avoid pointed tips



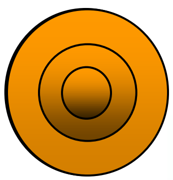
Avoid long narrow tips



Electrode face after cleaning:

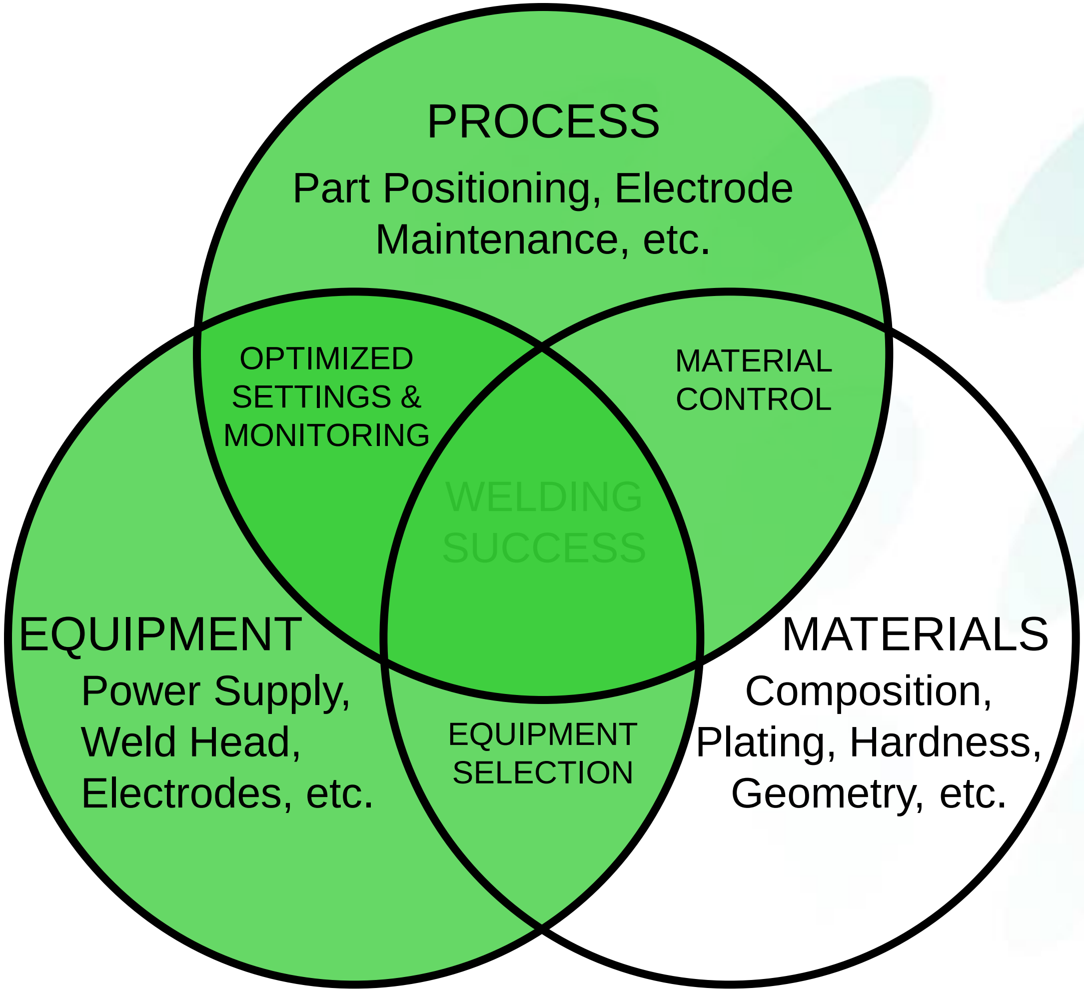


No change in heating



Increasing area = colder weld

Resistance Welding Diagram:



Process Audit Worksheet

MIYACHI UNITEK
1820 S. Myrtle Avenue
Monrovia, CA 91017-7133
(626) 303-5676 • FAX: (626) 358-8048
e-mail: info@miyachiunitek.com
http://www.miyachiunitek.com

Process Audit Worksheet

Note: To return to the DoE Tool, press ⇦ in upper left hand corner of this screen.

General:

Audited By: ______________________ Date: ____________

Plant: ____________ Station Number: ________ Job Number: ________

Power Supply Model: ____________ S/N: ________

Weld Head Model: ____________ S/N: ________

Initiation:

Weld Materials:

Material 1:	Top	Material 2:	Bottom
➢ Name:		➢ Name:	
➢ Part Number:		➢ Part Number:	
➢ Base Material:		➢ Base Material:	
➢ Plating Type:		➢ Plating Type:	
➢ Plating Thickness:		➢ Plating Thickness:	
➢ Size:	mm Thick	➢ Size:	mm Thick
➢ Approved Source:		➢ Approved Source:	

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) <u>Electrode Force</u>: *Increase force to shift heat away from contact areas, decrease force to shift heat to contact areas.*

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

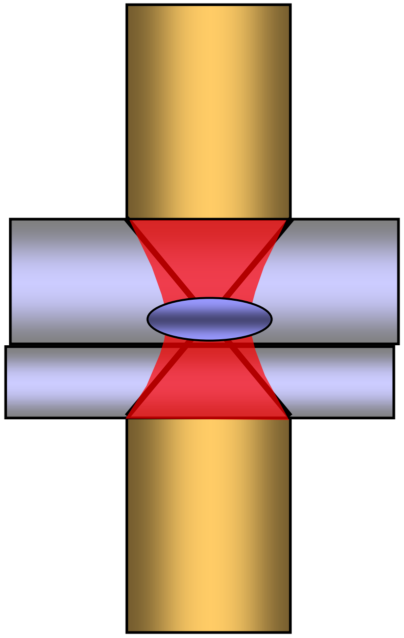
3) <u>Electrode Face Size</u>: *Increase electrode face size to shift heat away from electrode, decrease face size to shift heat toward electrode.*

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

5) <u>Electrode Materials</u>: *Use more resistive electrode to shift heat toward electrode, use more conductive electrode to shift heat away from electrode.*

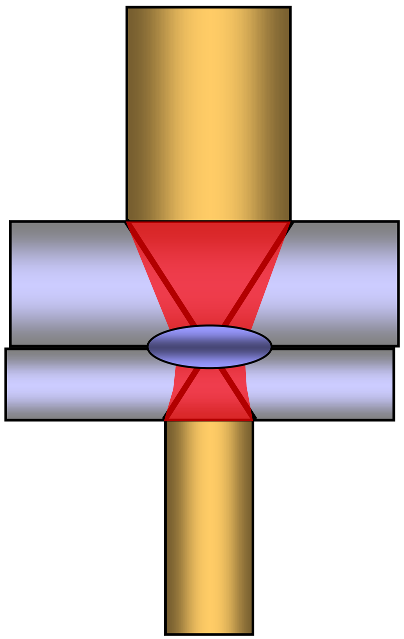
Heat Balance Examples

Electrode size

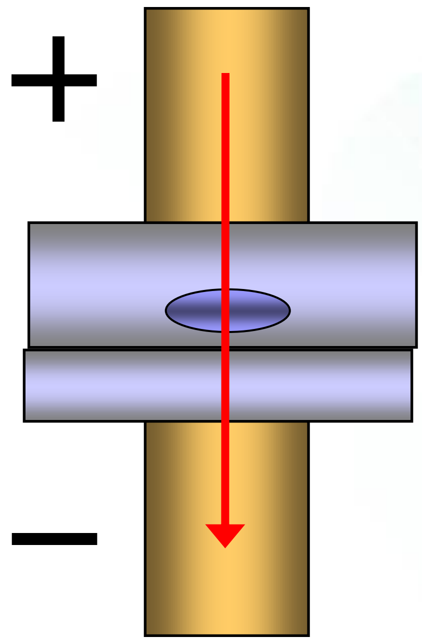


Heat Balance Examples

Electrode size

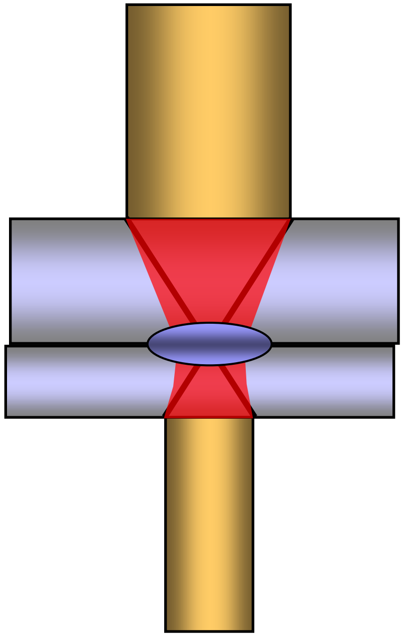


Polarity

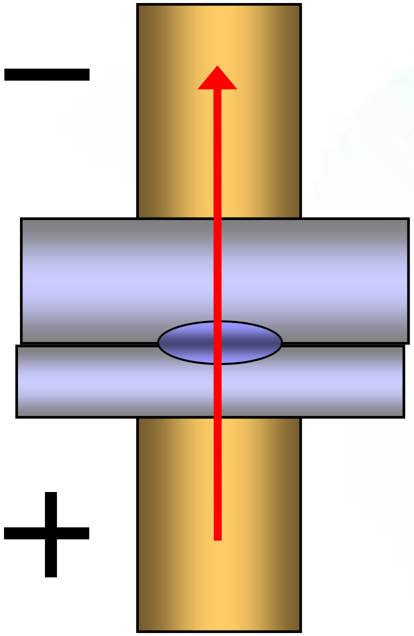


Heat Balance Examples

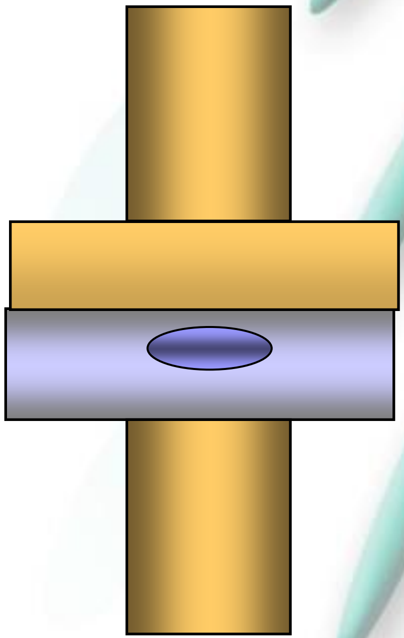
Electrode size



Polarity

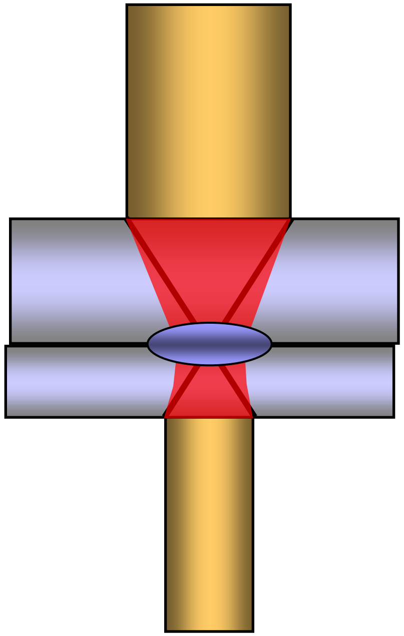


Electrode Material

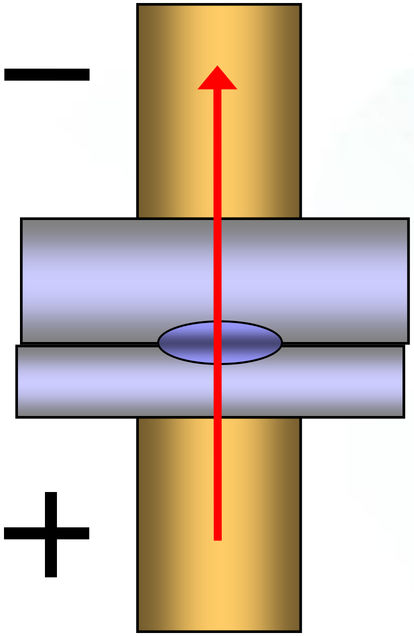


Heat Balance Examples

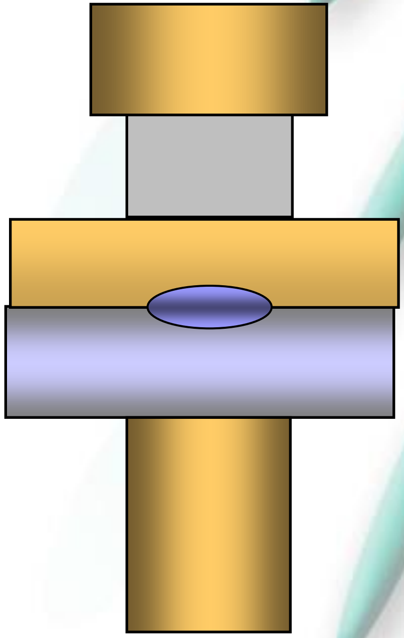
Electrode size



Polarity



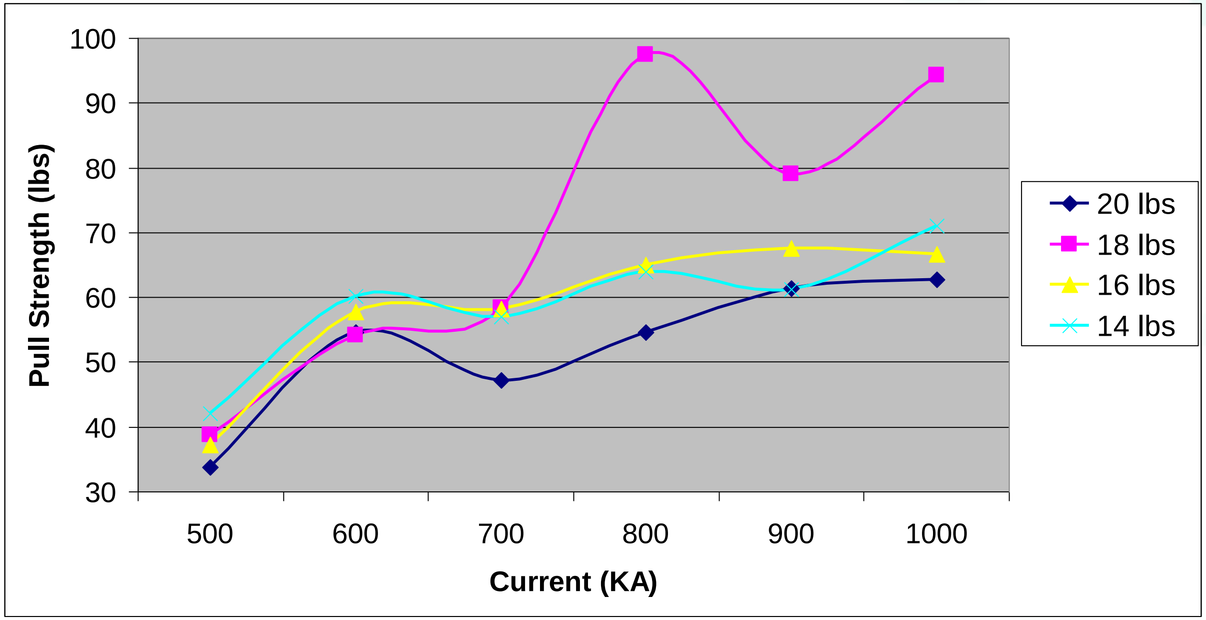
Electrode Material



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:

		Pull Strength						
Electrode	20	24.4	33.8	54.6	47.2	54.6	61.4	62.8
Force (lbs)	18	28.8	38.8	54.2	58.4	97.4	79	94.2
	16	22	37.2	57.8	58.2	65	67.6	66.6
	14	38	42	60.2	57	64	61.2	71
	12	54	54.6	63.2	52.2	62	47.2	53.6
	10	27.6	59.6	56.8	68.2	91.2	64.4	56.6
	8	22.8	54	51.2	47.8	51.4	55.6	50.6
	6	31.6	43.8	65.4	56.2	59.4	54	36
	4	35.6	38.6	56.8	56.8	51.8	46.8	53.4
Weld Current (A):		**400**	**500**	**600**	**700**	**800**	**900**	**1000**

Pull Strength of 60 lbs or Greater is Highlighted

		Weld Current		Displacement				
		400	500	600	700	800	900	1000
Electrode	20	1	3	4	6	8	9	12
Force	18	1	3	4	6	7	10	12
	16	2	3	5	6	8	10	12
	14	2	3	5	6	8	11	13
	12	3	4	5	7	9	11	14
	10	2	4	4	7	8	10	13
	8	3	5	6	7	9	11	14
	6	3	3	5	6	8	10	13
	4	2	4	5	6	8	11	14

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?*

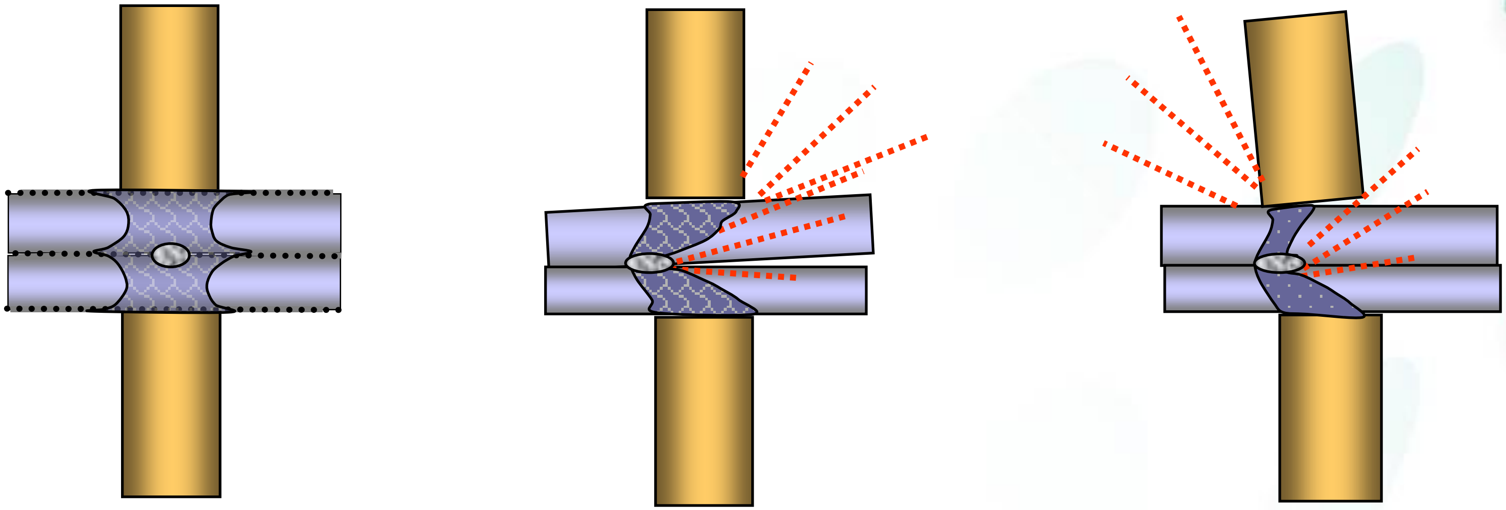
Process Pitfalls

90% of all welding process problems occur at the business end:

Material control

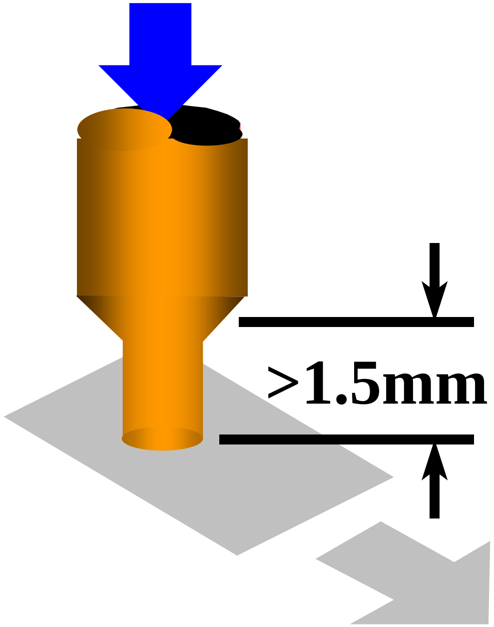
Part to part positioning

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

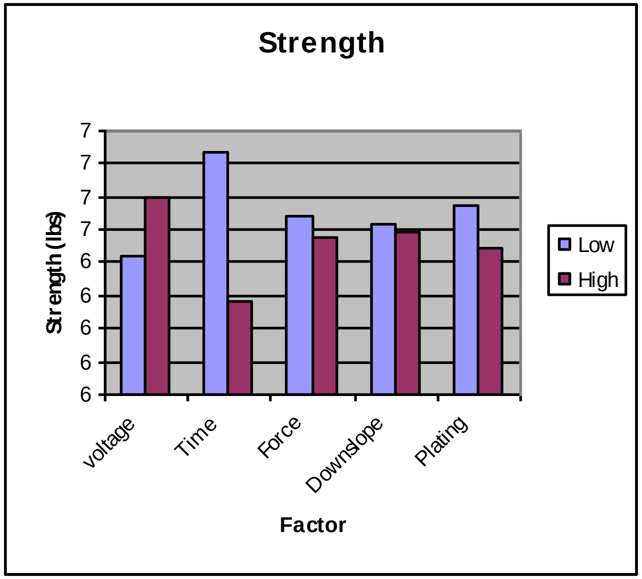
DOE Tool

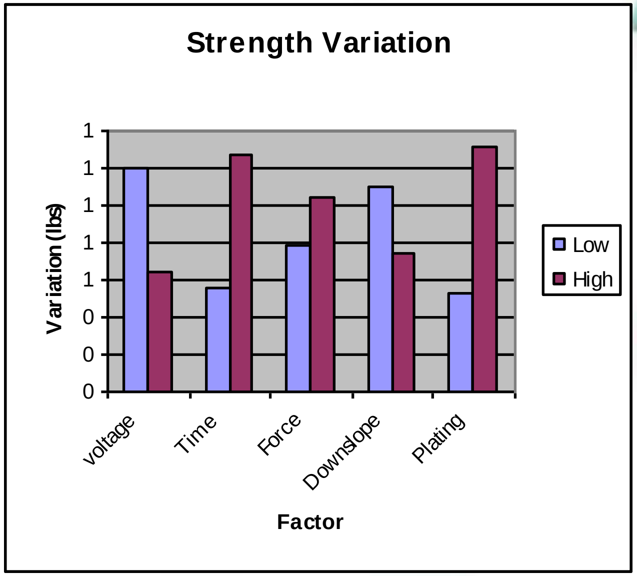
1820 S. Myrtle Avenue, P.O. Box 5033
Monrovia, CA 91017-7133
(626) 303-5676 FAX: (626) 358-8048
e-mail: info@miyachiunitek.com
http://www.miyachiunitek.com

Welcome to the Miyachi Unitek DoE Tool and Process Audit Worksheet.

Continue

Select Screening Factors:			
Factors	Settings		Units
	Low	High	
Voltage	1.00	1.12	volt
Time	2.80	3.10	msec
Force	1.70	2.00	scale
Downslope	1.00	3.00	msec
Plating	regular	heavy	mils





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

Overheating of Weldment	Discoloration	Weak Weld	Insufficient Nugget	Metal Expulsion	Sparking	Inconsistent Welds	Electrode Damage	Electrode Sticking

INSTRUCTIONS:

Push the buttons for the SYMPTOM OR PROBLEM. 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; insure all cable and other electrical connections are tight; replace broken flexures.

Use clean electrodes and materials. Insure electrode alignment with faces parallel

Exercise consistent process control over materials, equipment and the weld

Dress electrodes regularly and consistantly using 600 grit paper or polishing disk (no files).

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

Follow instructions above to determine best course of action.

Try simplest solutions/adjustments first.

Change only one variable at a time.

If one 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.

	CAUSE	PRIORITY	SOLUTIONS
POWER SUPPLY RELATED	Excess Current/Energy	1	Decrease current in steps of 5-10%
	Insuficient Current/Enery	N/A	Increase current in steps of 5-10%
	Excess Time	4	Decrease weld time in steps of 5-10% (N/A for CD)
	Insuficient Time	N/A	Increase weld time in steps of 5-10% (N/A for CD)
	Insuficient Squeeze Time	1	Increase squeeze time in steps of 20 milliseconds (1 cycle f
	Insuficient Hold Time	3	Increase hold time in steps of 20 milliseconds (1 cycle for A
	Insuficient Upslope	1	Increase upslope time in steps of 5 milliseconds (N/A for CD
WELDHEAD RELATED	Excess Force	N/A	Decrease force in steps of 10-20%
	Insuficient Force	1	Increase force in steps of 10-20%
	Poor Weldhead Follow-up	1	Use weldhead with fast follow-up and/or reduce mass of top
	Wrong Polarity	N/A	Reverse polarity of each electrode
MATERIAL RELATED	Poor Projection Design	3	Contact Unitek Equipment Applications Lab for assistance
	Poor Plating of or Oxidized Dirty Parts	2	Clean parts before welding. Check plating thickness and co
	Incompatible Metals	N/A	Change one metal or use third interface metal
	Requires Cover Gas	4	Use argon or similar cover gas.
	Parts Mis-positioned	2	Provide tooling/fixtures to hold parts in place.
ELECTRODE RELATED	Wrong Electrode Material	N/A	Check Electrode/Material Selection Guide.
	Dirty Electrodes	1	Clean electrodes and/or parts to be welded.
	Electrode Tip Shape	2	Use constant area electrodes or shape to suit application.
	Mushroomed Electrodes	N/A	Replace or reshape electrodes or increase cleaning schedul

MIYACHI UNITEK™

Common Material and Process Problems:

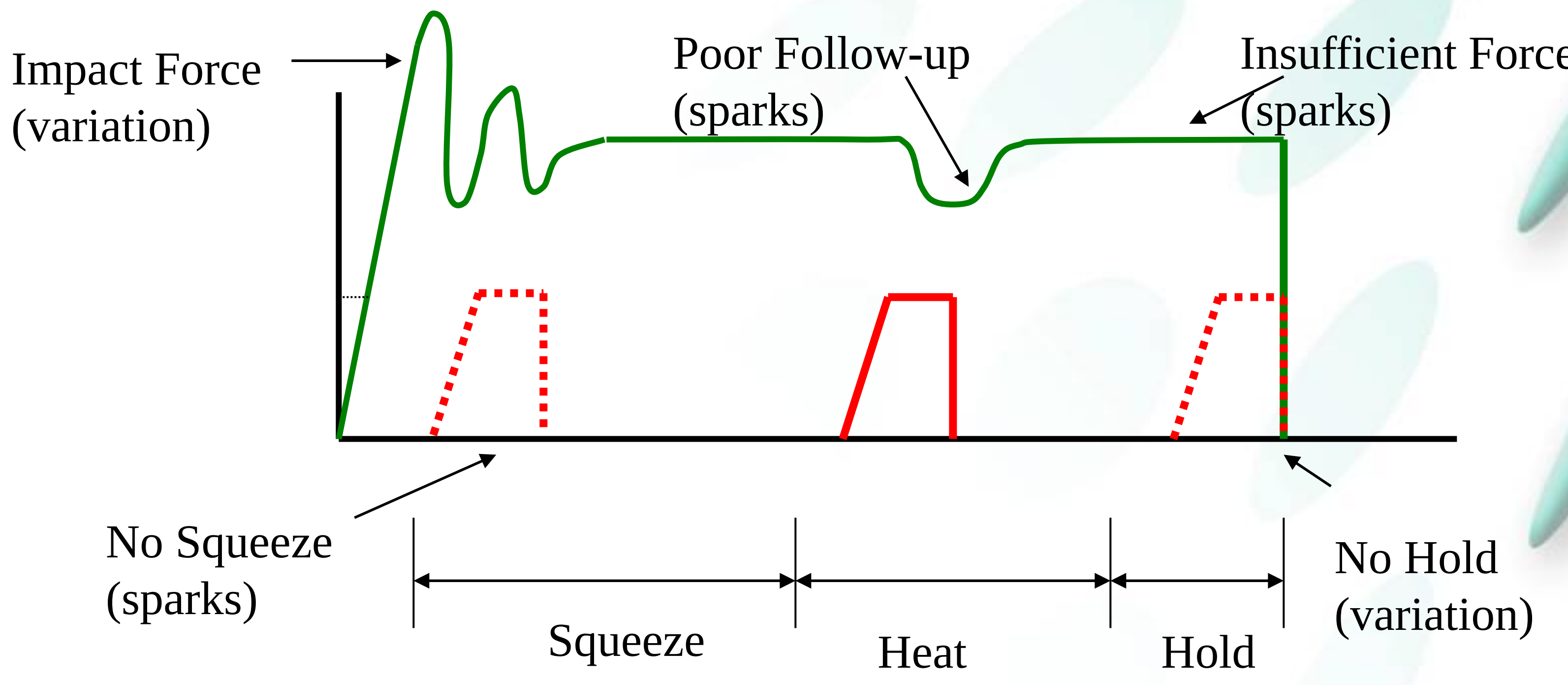
Materials:

- Material Substitutions
- Plating Inconsistencies
- Varying Surface Roughness
- Oxidation
- Contamination
- Thickness Changes
- Projection Inconsistencies
- Poor Design

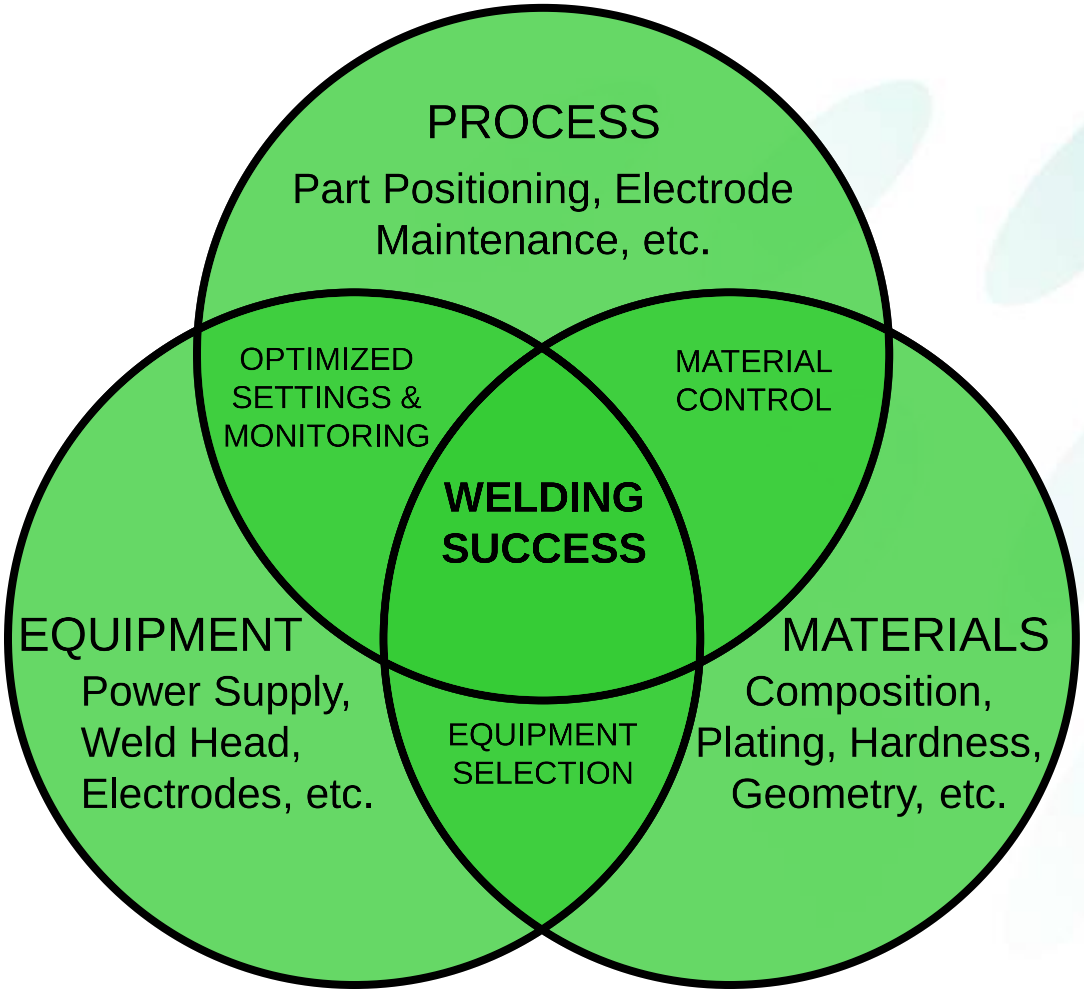
Process:

- 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



Resistance Welding Diagram:



Questions & Answers

Thank you for your time…