Welding Metrics

Economic Impact

Of

Collecting Welding Metrics On A

Hand Held PDA

Why is Economics of Welding Important?

- Cost of Over & Under Welding
  - Non Value Added time is impacted
  - Labor is the most cost
- Welding Should Be a Profit Center – Not a Cost Center
- Insight Was Gained By
- The American Welding Society's (AWS)
  Certified Welding Supervisor (CWS)
  Course Which Addresses This Cost Issue
- Contributions From Internal & External Consultants and Professionals
- Most Welders & Supervisor's Think More Is Better

SOMETHING TO THINK ABOUT

- Few welding operations are controlled by management.
- Cost of welding operations:
  - 85% Labor & Overhead
  - 9% Material Costs
  - 4% Equipment Investment
  - 2% Power &\or Gas
  - Non-Value Added Time

  94% of welding costs are labor & material!
- *Following Chart Shows Over Welding Costs*

Why is Economics of Welding Important?

Cost of Over Welding Fillet Welds

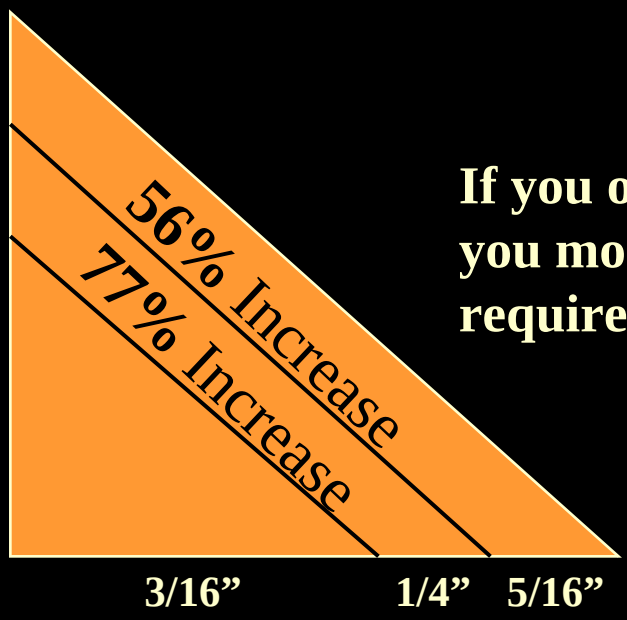
3/16” Area = .01757 sq. inches

1/4” Area = .03125 sq. inches

5/16” Area = .04882 sq. inches

Difference of .01368 $\frac{.01368}{.01757}$ = 77%

Difference of .01757 $\frac{.01757}{.03125}$ = 56%



Note:

If you over weld a required 3/16” fillet, with a 5/16 fillet, you more than double (100%+ increase) the amount of filler required, and more than double the man hours required.

EXAMPLE
We are going to compare 3 welders

- Assume:
  - Labor rate is $42.00 an hour
  - Flux core wire is $1.25 Pound
  - Flux core has an 85% deposition efficiency
  - Carbon steel has a density of 0.283 # p.c.i
- We are going to ask all 3 to:
  - Give us a 3/16” fillet
  - Run it at 250 amps (Horizontal & Flat)
  - Give us a 45% arc time
  - Work an 8 hour day expecting 496 feet of weld

ARC TIME

- Notice in our example we asked for a 45% arc time. National norm is about 19%. But that is based on averaging all positions which lowers the average. Also includes multi-craft processes.
- Welders like to brag and if you asked them how many hours or minutes of a day or hour they weld, they would probably tell you about 75%.
- Let me point out 45% is 27 minutes of each hour or 3 hours 36 minutes of an 8 hour day.

WELDER "A"

- Gives us a 3/16" fillet at 250 amps with a 45% arc time
- .1875 x .1875 x .5 x 12 = .0596 # /ft.
- 500 feet x .0596 # =29.8 #
- 85% deposition efficiency = 35.05 #
- At 250 amps depositing 8.2 pph , welder A can weld 137.6 ft/ hr. at 100% arc time
- 8 hour day 1100 feet but at 45% arc time he can weld 495 feet a day. (Baseline)
- 35.05 # x $1.25 = $43.82 consumable cost.
- 8 hours labor at $42.00 hr. = $336.00
- Welder A's cost = **$379.82**

WELDER "B"

- Slightly over welds and gives us a ¼" fillet
- He welds at 225 amps
- Gives us a 35% arc time
- .250 x .250 x .5 x 12 x .0283 =.106 #/ft.
- 500 feet x .106# = 53.06 #
- At 85% deposition efficiency = 62.4 #
- At 225 amps will deposit 7.0 #/hr.
- 53.06# I7.0 =7.58 hrs. at 100% arc time.
- At 35% arc time = 21.65 hrs.
- 62.4 # wire at $1.25# = $78.00
- Labor at $42.00 x 21.65 hrs. = $909.30

Welder B's cost = **$987.30**

WELDER "C" (REAL LIFE)

- Over welds and gives us a 5/16" fillet
- He welds at 180 amps
- Gives us a 20% arc time
- .3125 x .3125 x .5 x 12 x .0283 =.165 #/ft.
- 500 feet x .165# = 82.9 #
- At 85% deposition efficiency = 97.5 # required
- At 180 amps will deposit 5.08 #/hr.
- 82.9# I5.08 =16.31 hrs. at 100% arc time.
- At 20% arc time = 81.6 hrs.
- 97.5 # wire at $1.25# = $121.86
- Labor at $42.00 x 81.6 hrs. = $3,477.20

Welder C's cost = **$3,599.06**

NOW LET'S COMPARE

- Welder A = $379.82
- Welder B = $987.30
- Welder C = $3,599.06
- Which welder do you want working for you?
- How can you control this?
- Management establish budgets & training
- Take another look at your training policy
- Monitor arc time (reduce motion & delay)
- Monitor amperage & voltage
- Monitor weld size
- Report, analyze & continuously improve.

Bells Should Be Going Off!

- Welder A is no pie in the sky, he or she is realistic and attainable!
- Welder C is status quo if you're lucky!
- Difference in Welder A & C's productivity cost was almost 10 times higher or 947%.
- That should raise a red flag or make bells & whistles go off!

Do the Numbers – Shocking!

- Suppose you have 100 Welder C's, who average a 45 hour week at $42.00/hr. and you can convert them to Welder A's, your cost savings for labor & consumables would be astronomical.
- $379.82 x 5.5 (days) x 52 weeks x 100 welders versus
- $3,599.06 x 5.5 (days) x 52 weeks x 100 welders.
- ***You do the Math!***
- ***You will be shocked!***

Other Benefits of Metrics

- Found That Reducing Over Welding and Paint Over Spray Reduces Smoke/Gas and Fume Emissions – Which EPA is Excited About.
  - Found That Reducing Over Welding and Paint Over Spray Reduces Welding Smoke/Gas and Paint Fume Emissions – Which EPA is Excited About.
  - Also found we can apply concepts to painting & other work processes that may produce release of products into the environment.
  - Keep processes Specifications Save Cost and Emission Levels

Environmental Savings

- Example of What Can Be Done By Reducing Over Welding:
  - Majority of our welding is FCAW with 100% CO2 shielding gas.
  - FCAW has an 85% deposition efficiency which means 15% goes off into atmosphere.
  - Welding wire lbs. per / man hours welding has gone down 40% because of more efficient & applying lean concepts.

How It Related To Bender

- Welding wire contains approximately 1.72 pounds of manganese (1.7) and nickel (.02) compounds per 1,000 pounds.
- We used 230,000 lbs. Last year which equates to approximately 400 lbs. plus approximately 44,000 pounds of CO2.
- A 40% reduction would reduce compounds by 160 lbs. and gas by 18,000 lbs.

OK! How Do We Do This?

- 1St – Welding Work Must Be Broken Down During Planning to the Weld Joint Level
  - Activity Steps if Using Primavera Planning Tool
- Each Step Budgeted
  - Using the Barckhoff Operating Factor Method.
- Once Steps Are Budgeted Use Welding Metrics Software To Collect Pertinent Data
  - Weld Size Readings & Amps Used on Joint
- The Following Slides Present An Overview of the Functionality of the Metric Software Used To Collect Data & Produce Cost Reports of Welding Inaccuracies

Contributors To Welding Metrics

Contributions & Continual Collaboration

Dale Jermyn	*– 37 Years Shipbuilding & PM*
Jackie Morris	*– 27 Years Shipbuilding QA/EPA*
Don Lynn	*– 30 Years Welding Engineering*
Ron Pierce	*– 40 Years Successful Welding*
Craig De Lisle	*– 25 Years "IS" In Heavy Industry*

"Over 150 Years of Experience"

If You Can't Measure It – You Can't Control It!

Demonstrate the process and verify the results before you invest in the process!

CDL1

Jackie Morris

Craig De Lisle, 1/5/2006

Hierarchy System Implementation

- ***Planned Activities – Broken Down Into Steps***
  - ***Step Budget(s) Rolls Up To Activity Budget***
- ***Metrics – Measures Process & Operations Efficiency***
  - ***Provides Foreman Real-Time Feed Back***

    Can Be Used For:

    Welding, Fitting, Paint, Electrical, Piping, Etc.
- ***TMS*** *(Task Management System)*
  - ***Collect Physical Progress***
  - ***Calculates Earned*** *(Update Earned Steps To Employees)*
  - ***Detail Reports***

    Job, Area, Foreman, Employee

CDL

CDL10 Jackie Morris

Craig De Lisle, 1/5/2006

Hierarchy System Implementation

- ***TMS Labor Distribution***
  - ***System Has The Capability To Automatically Prorate The Foreman's Labor Distribution Using % Complete As Compared To Budget Value of Step***
  - ***Prorating Increases The Accuracy Of Proper Time Charging***
- ***Audit***
  - ***Perform Internal Or Q/A Audits To Verify Process Collection Accuracy***
    - ***Supports ISO 9001***
    - ***EPA – Lean / EPA Initiatives***
    - ***Navy – Process Control Concerns***

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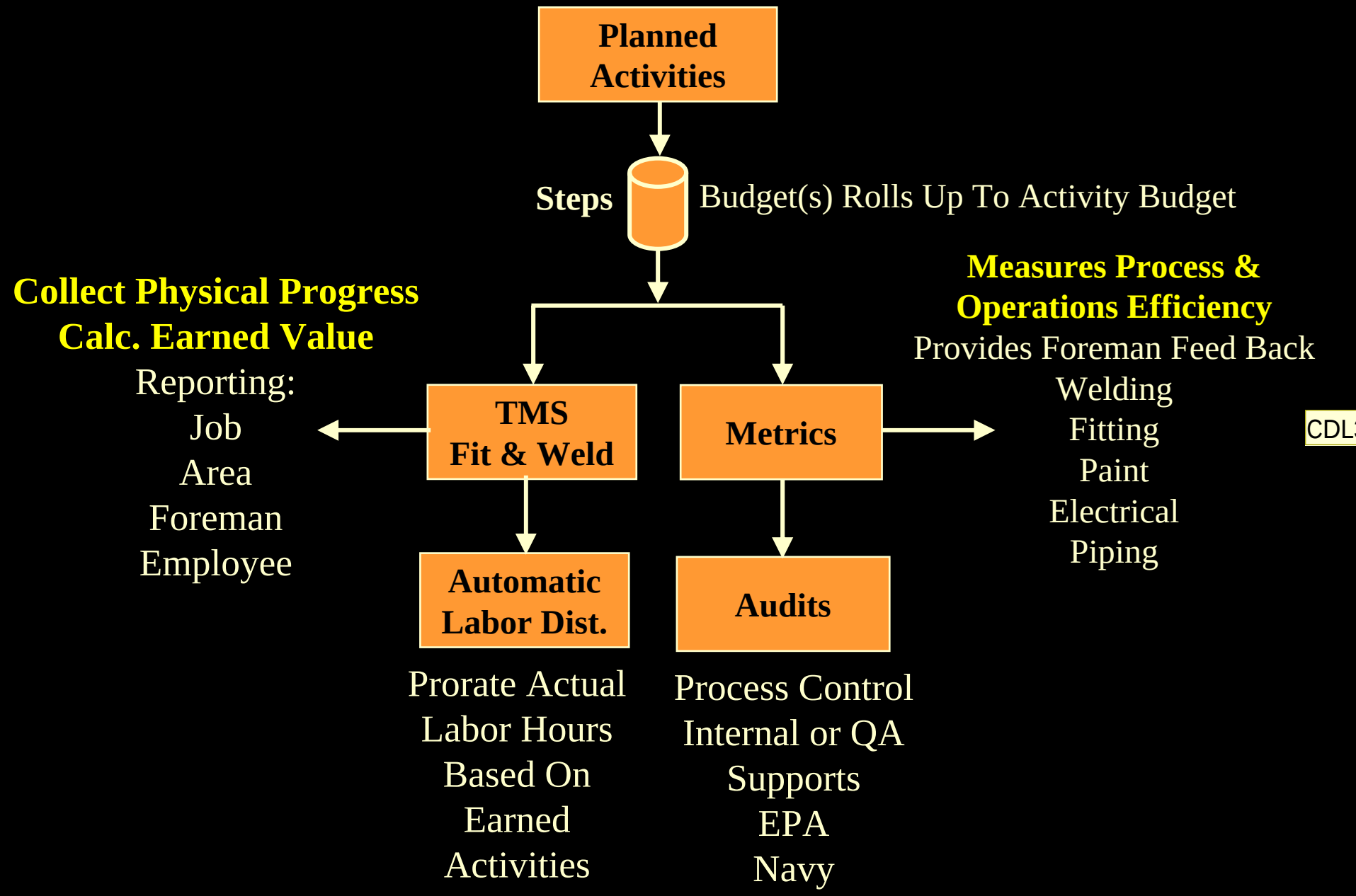
Process Strategy



Automatic Welder Certification Checking By Weld

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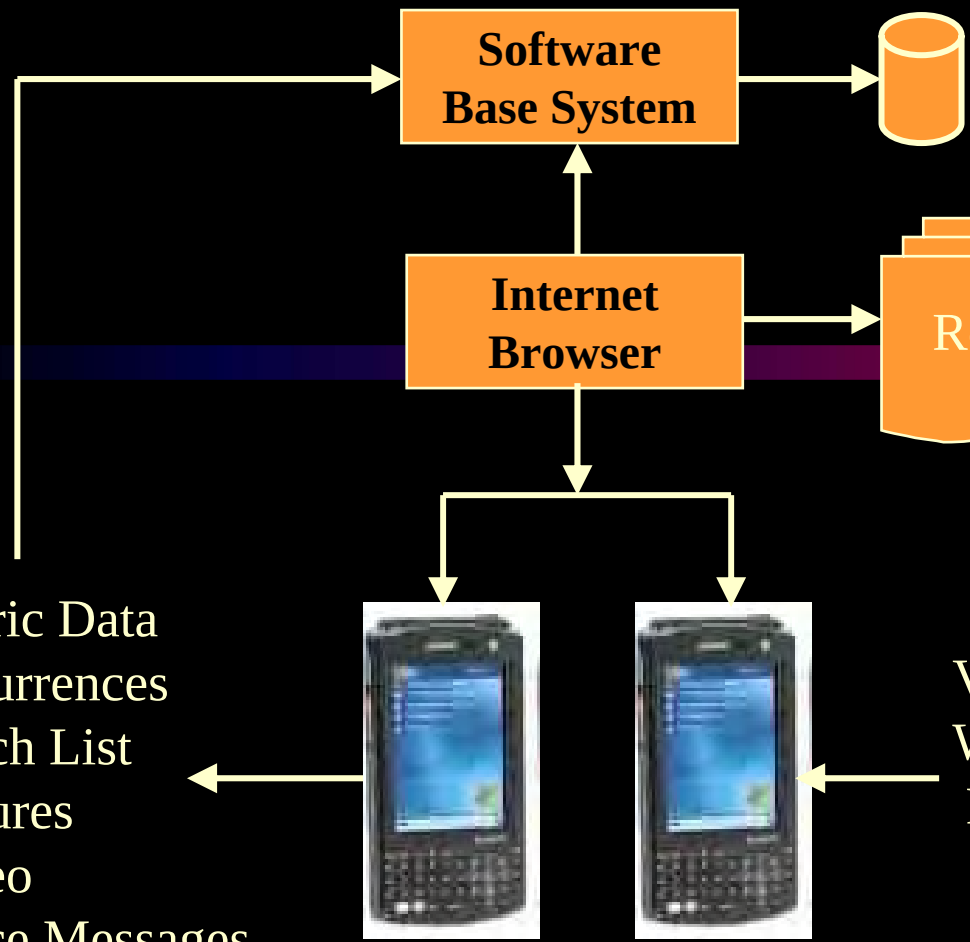
Overview Of Metric System

Internet Based Architect & Support



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Internet Service Provides

Instant Connectivity To Host System Through Internet

- *Secure Sign On & Data*
  - *Socket Security 32 bit encryption – (like the bank)*
- *Copy of data base data upon request or automatic to your server*
- *Download metric data to xls, sql, sybase, text….*

Instant Metric Data Entry From Anywhere In The World

- *Sign in and view & print reports on metrics from:*
  - *Office, Hotel, Home*
  - *Same support from technical team or supporting consultant*
- *E-mail notification of critical metrics*
- *Notification of critical messages through phone (future)*

Internet Support

- *PDA Diagnostics*
- *Auto-Update of PDA programming changes*
- *Auto-Update of PDA database changes*
- *Using technology that has 70% of market share*
- *Programmed in .Net Visual Basic (Microsoft)*
- *SQL & Sybase databases*

Purpose Of The Welding Metrics

Provide A Method To Easily & Cost Effectively Collect Various Metrics

Foreman / Supervisor PDA Training takes 30 minutes

Provide Instant Feedback To Foreman

Ensures Company Standards Are Being Attained/Sustained

Minimum Number of Daily Metrics are Recorded

By Location, Area, Foreman and Employee

Can Be Tied To Step or Task

Provides Management With Additional Auto- Generated Data

XLS Graphs, Cost Overruns, Productivity, Trend Charts, Pareto Charts

The Benefits of a Metric

If Data Input Is Cost Effective, Why Not Use It

Collect metrics while supervisor reviews “Work-In-Progress”

Data input is designed to following fabrication and assembly tailored operations

Strategy of the Metric

While supervisor is performing walk around, collect as many variables as possible

Welding (amps, actual weld size, etc.)

As metrics are collected, calculate potential budget overruns

(Continued on next form)

The Benefits of a Metric

What is in place now to ensure "Operational Process Effectiveness?"

How are you now technically tracking the effectiveness of an operation without collecting and checking on the work in progress?

How are you monitoring non-value added work?

Work that is performed where no employee budget hours are earned.

How are implemented lean manufacturing techniques monitored?

Identify & Enter Occurrences (Problems) While Collecting Metrics

When problems are discovered during metric data entry supervisor will have the ability to enter an occurrence against the operation

(Continued on next form)

The Benefits of a Metric

Additional Work May Be Entered Into "The Punch List Sub-System"

Record outstanding work details that can be printed and followed up by supervisor

Target Areas of Concern

Turn Metric recording on/off in areas of concern based on performance data

Record & Report Metrics at Different Levels

By Job, Area, Location, Work Station, Employee, Operation, Procedure

(Continued on next form)

Data Entry Techniques

In the following example is the strategy behind collecting weld information. We wanted the foreman only to collect minimum information while returning the most results

Foreman ONLY Records in the PDA the Amps & Actual Size Of a Weld.

- *Selects the step or enters the Length of the Weld.*
- *Selects from a drop down the actual size of the weld readings taken.*
- *Enters in amperage reading (a separate metric measurement)*
- *The system automatically determines*
  - *The weld length of each size for each of the following*
    - *The number of feet over welded*
    - *The number of feet under welded*
    - *The number of feet of planned weld*
  - *Metal deposit of weld*
    - *Calculates Pounds of Metal Budget*
    - *Calculated Pounds of Metal Over or Under*
    - *Compares the two readings*

(Continued on next form)

Data Entry Techniques

Labor calculations

- *Calculates cost of labor for entire weld*
- *Calculates cost of labor for feet over welded*
- *Calculates cost of labor for feet under welded*
- *Compares the readings*

The supervisor at the time of the recording knows:

- How efficient the employee was
- If additional work needs to be performed
- If a problem occurrence needs to be entered
- If additional work needs to be entered into the punch list sub system
- And based on judgment if this work will impact the schedule

Graphs, Trends, & Pareto Charts

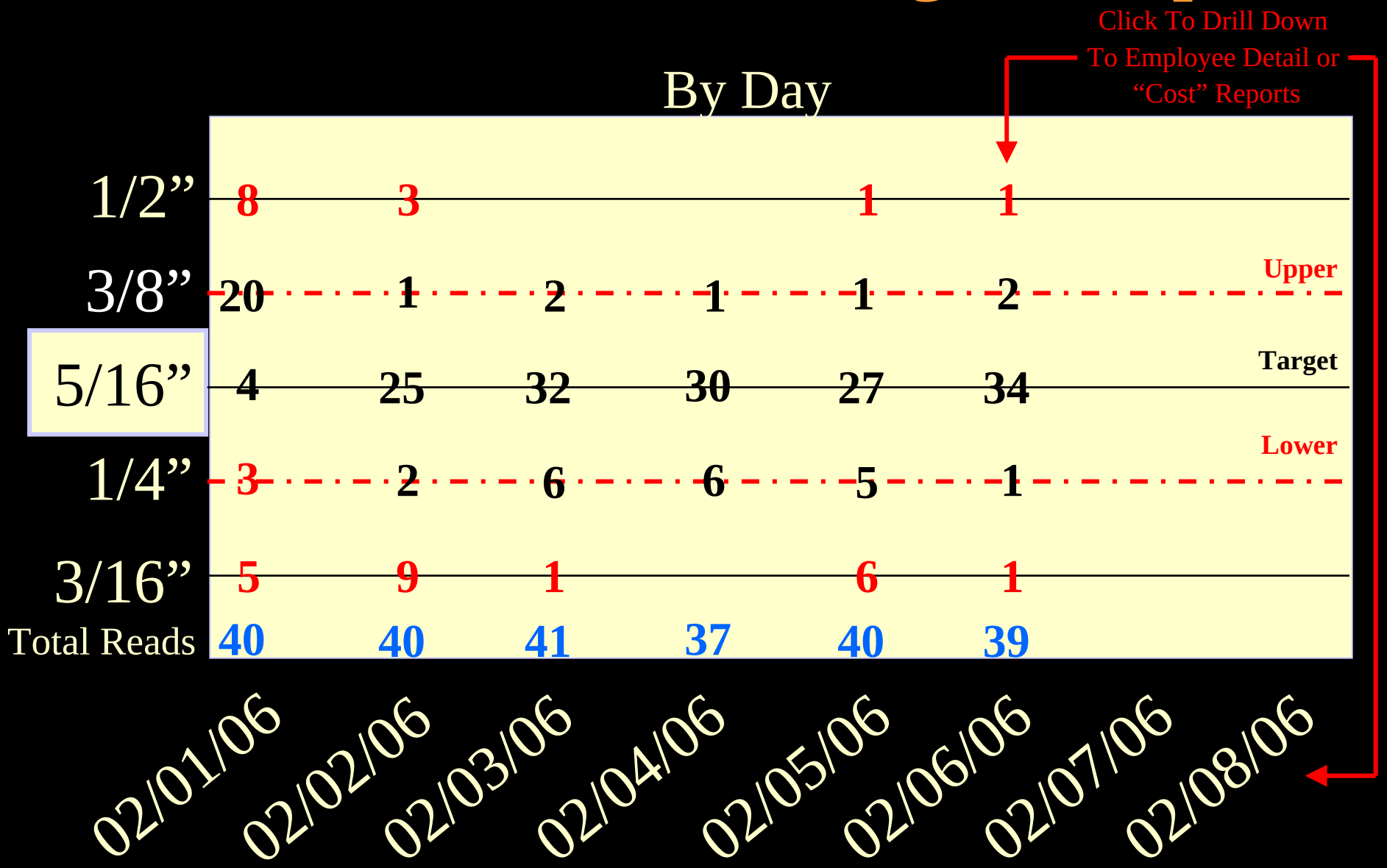
Easily create various types of graphs and charts that summarize metric and problem occurrence data to verify that standards are being maintained.

This also ensures that data collection process is being sustained. Too many times processes will be implemented which slowly fade away.

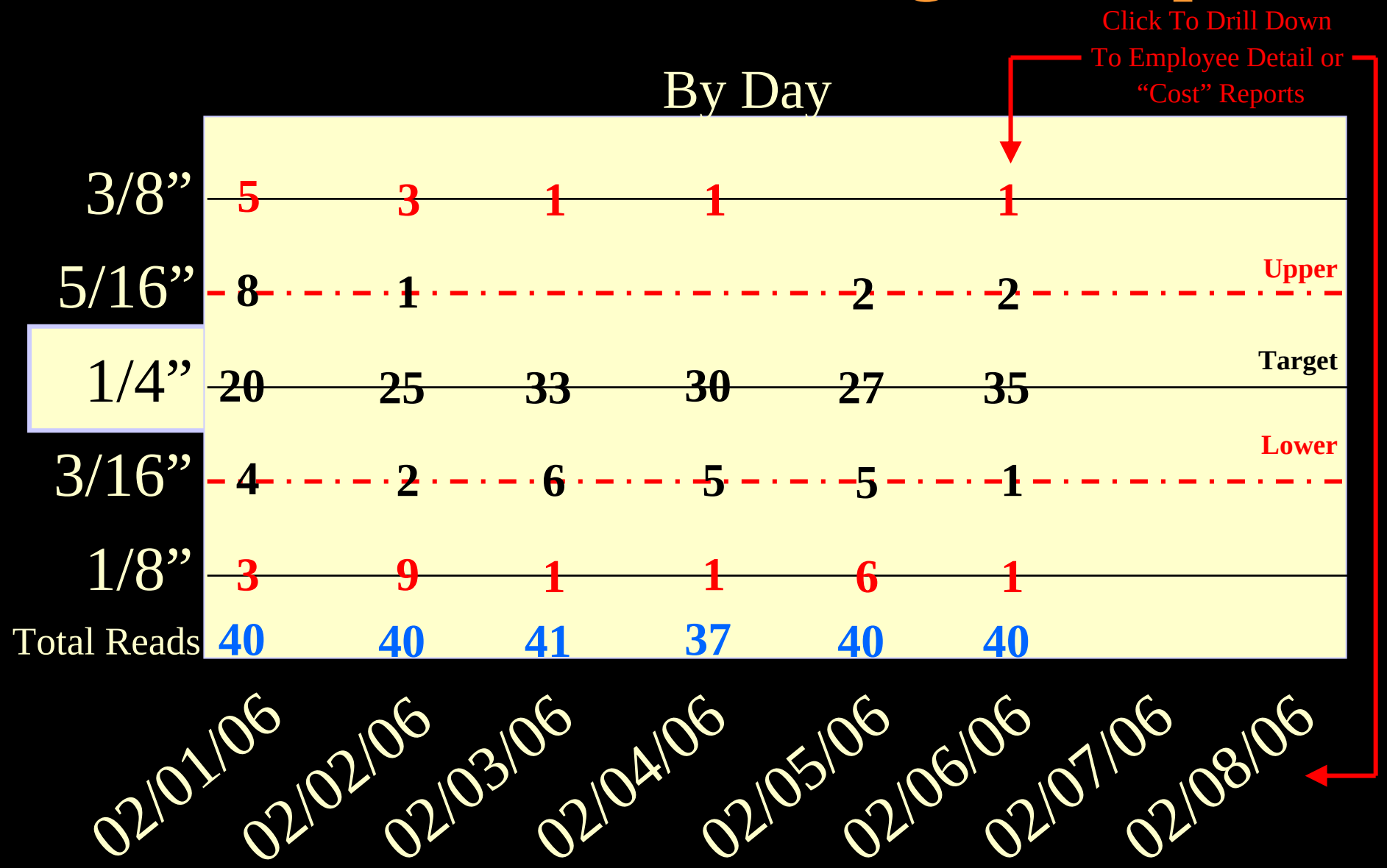
In the following example this charts quickly demonstrates

- Metrics were collected for each day except on the 16th
- Two days had an abnormal amount of over sized welds
- For days that had over sized welds you can quickly print and determine
  - How much costs were lost?
  - Where did these welds occur?
  - Who performed the welds?

Over & Under Welding Example



Over & Under Welding Example



Over & Under Welding Example

Click To Drill Down
To Employee Detail or
"Cost" Reports

By Week Or Month Ending

	02/03/06	02/10/06	02/17/06	02/24/06	03/03/06	03/10/06
3/8"	11	8	4	5	7	9
5/16"	13	15			11	15
1/4"	170	172	201	195	198	204
3/16"	23	21	16	15	8	4
1/8"	21	22	19	15	16	18
Total Reads	238	238	240	230	240	240

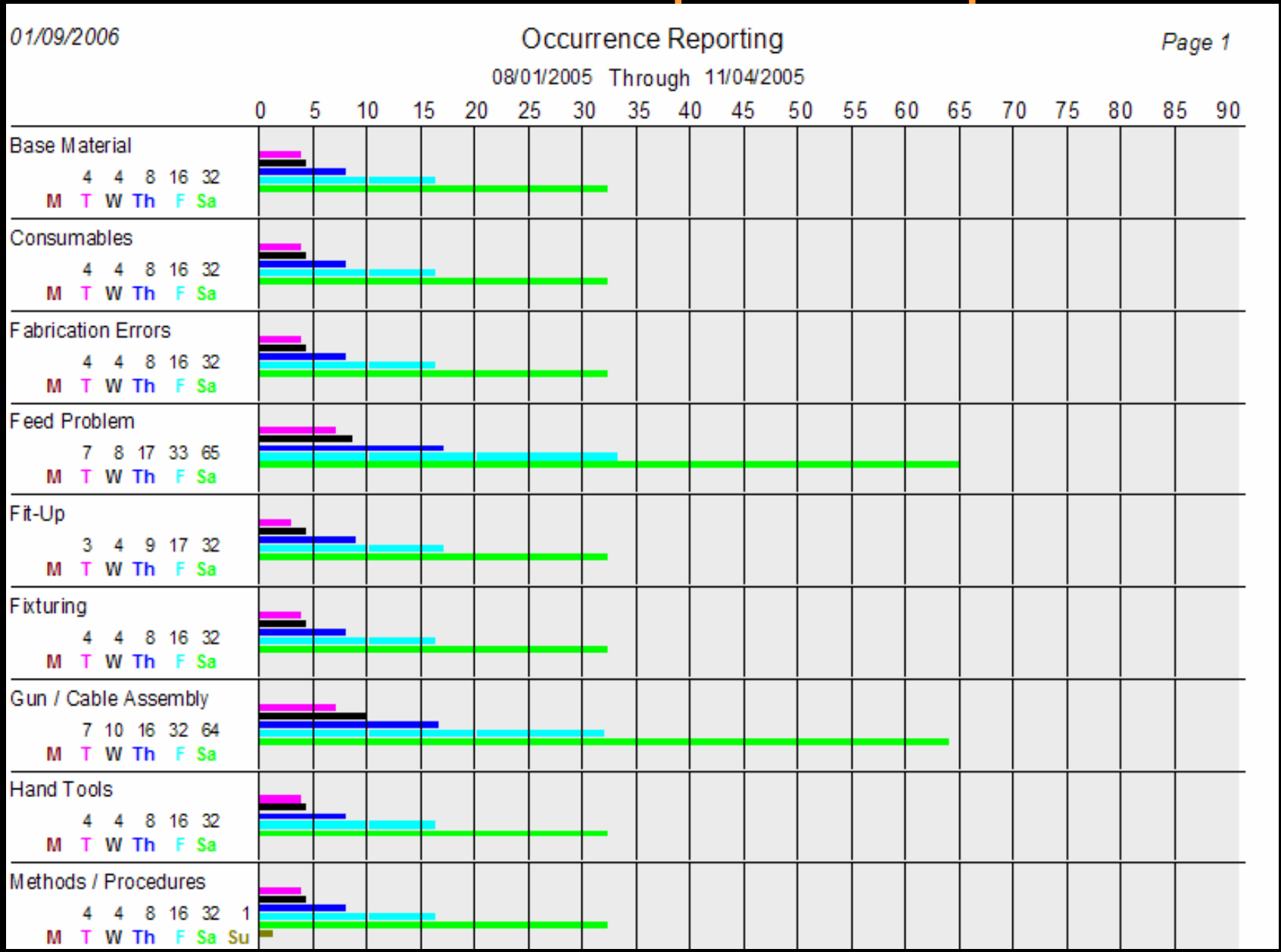
Upper

Target

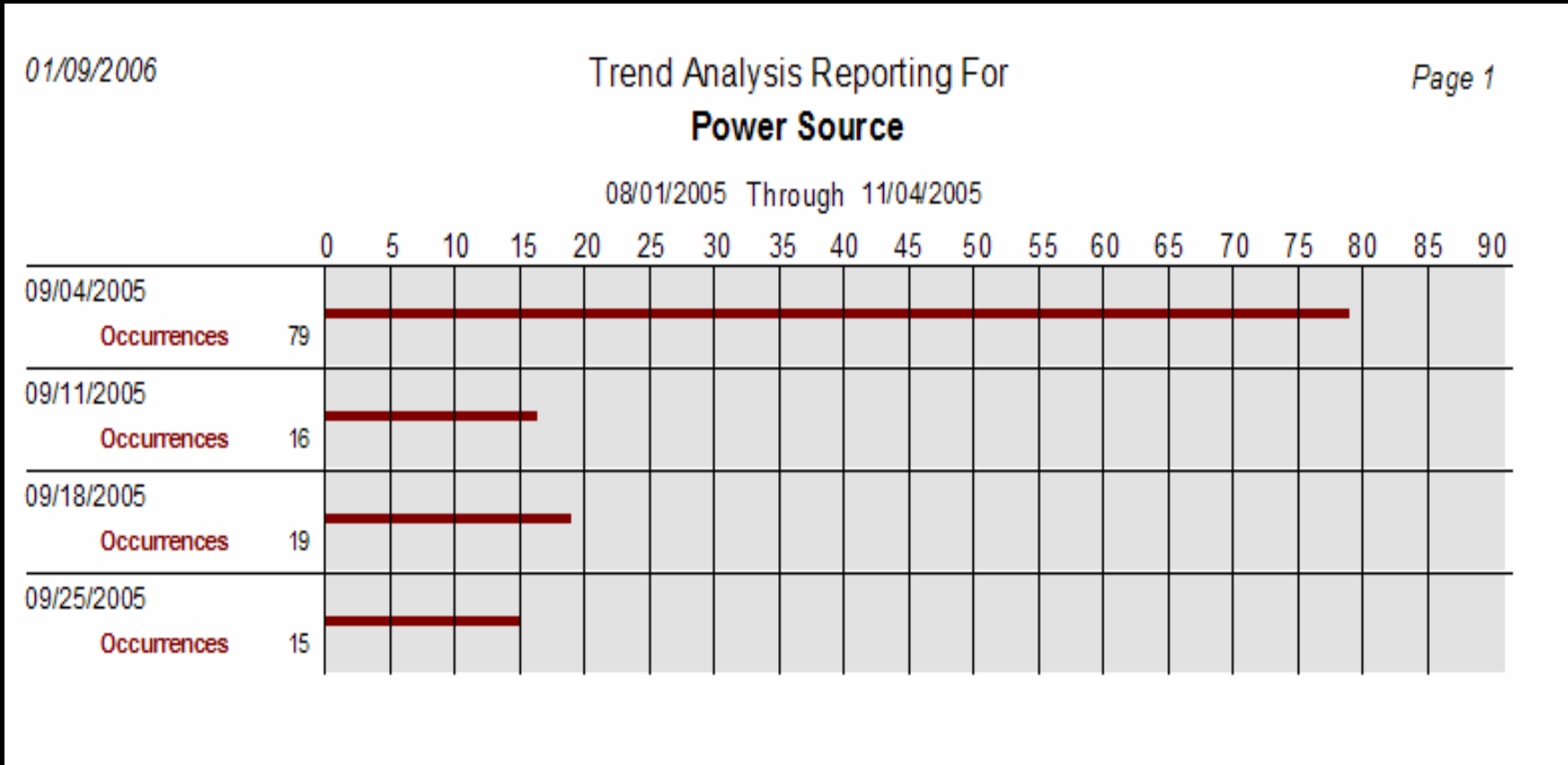
Lower

02/03/06
02/10/06
02/17/06
02/24/06
03/03/06
03/10/06
03/17/06
03/24/06

Occurrence Report Sample



Trend Report Example



Taking Amp Reading With Digital Clamp Meter

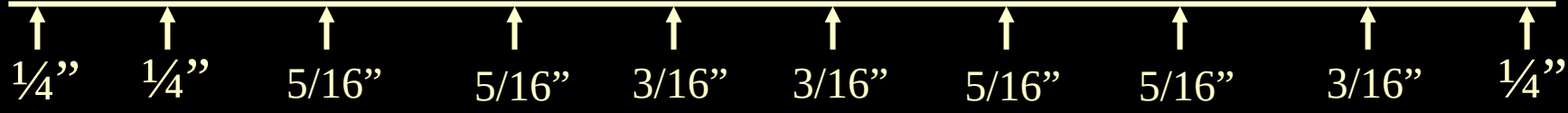
Taking Amp Reading On Welding Machine Meters

Example of Taking Weld Size First Leg – Horizontal Position

Example of Taking Weld Size Second Leg – Vertical Position

Over/Under Footage Automatically Is Calculated

50 ft ¼” Planned Weld



Size	No. Of Readings	Automatically Calc. Footage (10 Readings, 5 ft. each)	
1/4 Inch	3 Planned	15 feet	
5/16 Inch	4 Over Weld	20 feet	
3/16 Inch	3 Under Weld	15 feet	(Loss Factor Of 3)

	Read	Pounds To Deposit	Wire To Purchase	Metal Cost	LBS Deposited Per Hour	Arc Time	Labor Cost	
Planned	50	5.31	6.2	$7.80	8.2	0.65	$60.40	**Planned**
Actual	15	2.49	2.9	$3.66	8.2	0.30	$28.31	**Actual**
Over	20	3.32	3.9	$4.88	8.2	0.4	$37.75	**Over**
Under	15	3.18	3.7	$4.68			$54.36	**Under**
		8.99	13.1	$16.34			$126.45	**Total**
		-3.68	-6.8	-$8.53			-$66.06	**Difference**
		Deposition Eff. Rate	Machine Amps	Operating Factor	Labor Unit Rate			
		85%	250	45%	$42.00			

CDL8

Jackie Morris

Craig De Lisle, 1/5/2006

Loss Of Productivity Cost Factors

- **Under Welding**
  - *Cost Of Original Weld Material & Labor*
  - *Loss Of Material For Re-Work*
  - *Loss Of Labor For Re-Work*
  - *Loss Of Move & Setup Times*
  - *Loss Of Opportunity For Productive Time*
- **Over Welding**
  - *Cost Of Original Weld Material & Labor*
  - *Loss Of Over Weld Material*
  - *Loss Time Of Labor For Over Weld*
  - *Loss Of Opportunity For Productive Time*

Detail & Summary Reports

Welding Metric Details
By Employee
02/15/2006 to 02/15/2006

Badge	Name	Date	Planned Size		* --- Readings ---- *		
100	Dale Jermyn	02/15/2006	1/4"	50ft	1/4"	3	15 ft
					5/16"	4	20 ft
					3/16"	3	15 ft

Sample PDA Screens

Main Menu

Category

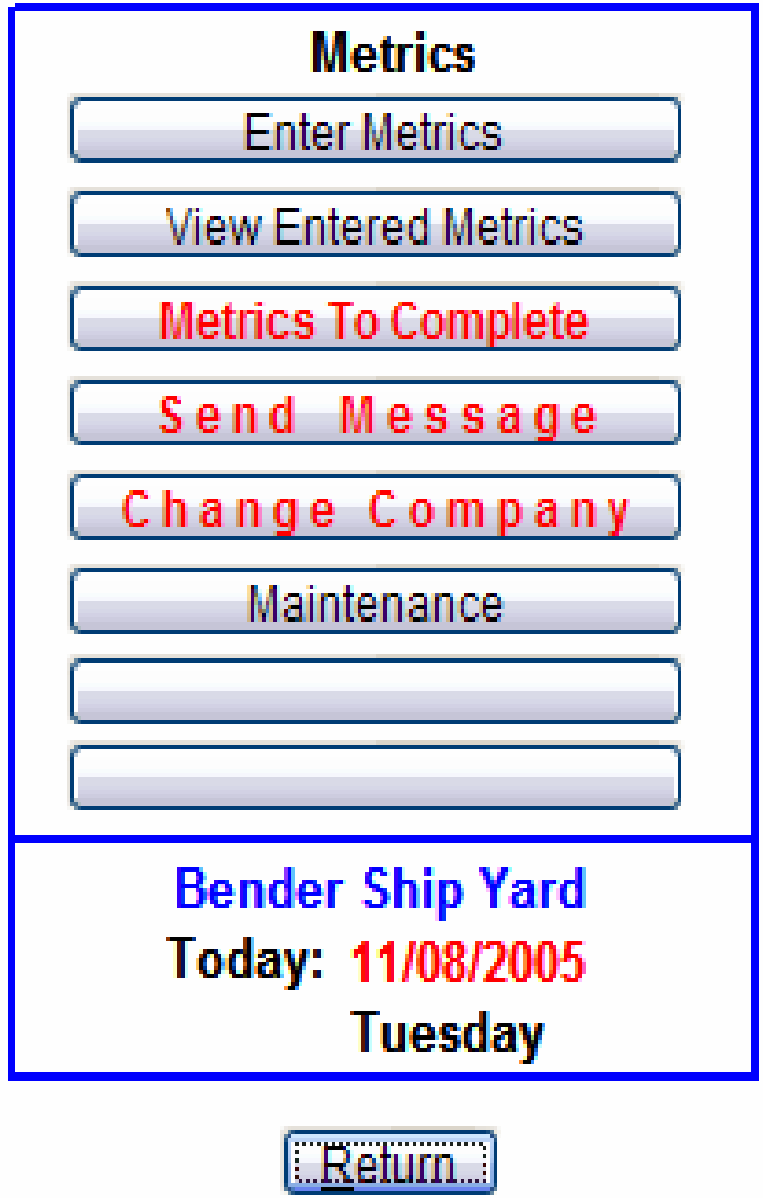
Weld Type

Completed

Step / Task

Weld Size

Weld Length



Category →

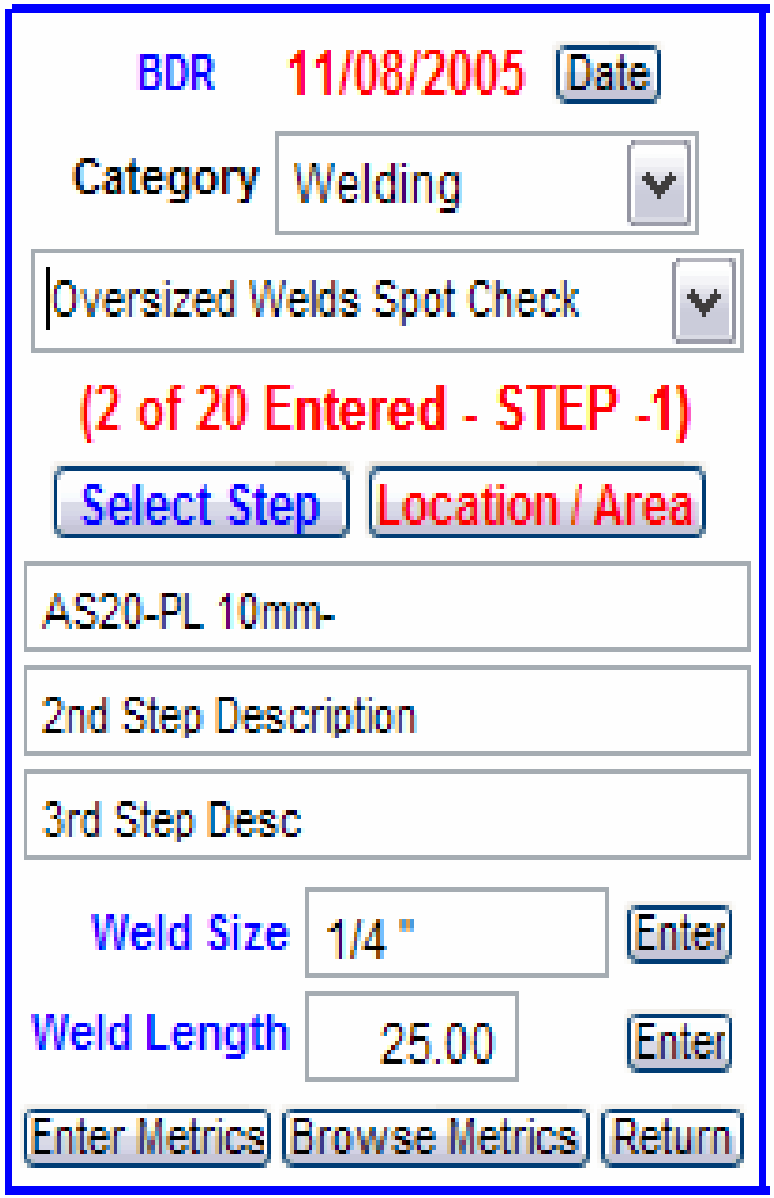
Weld Type →

Completed →

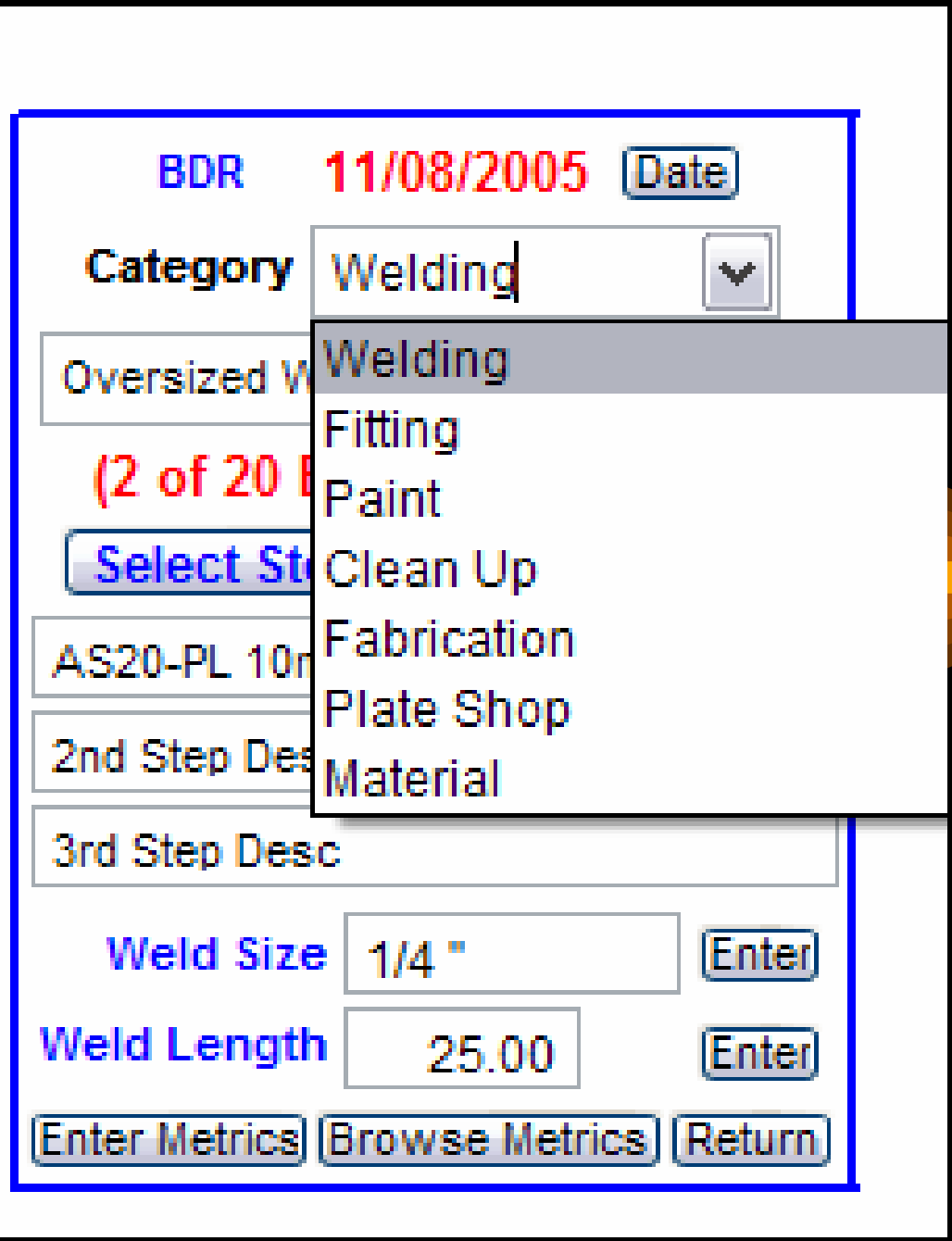
Step / Task →

Weld Size →

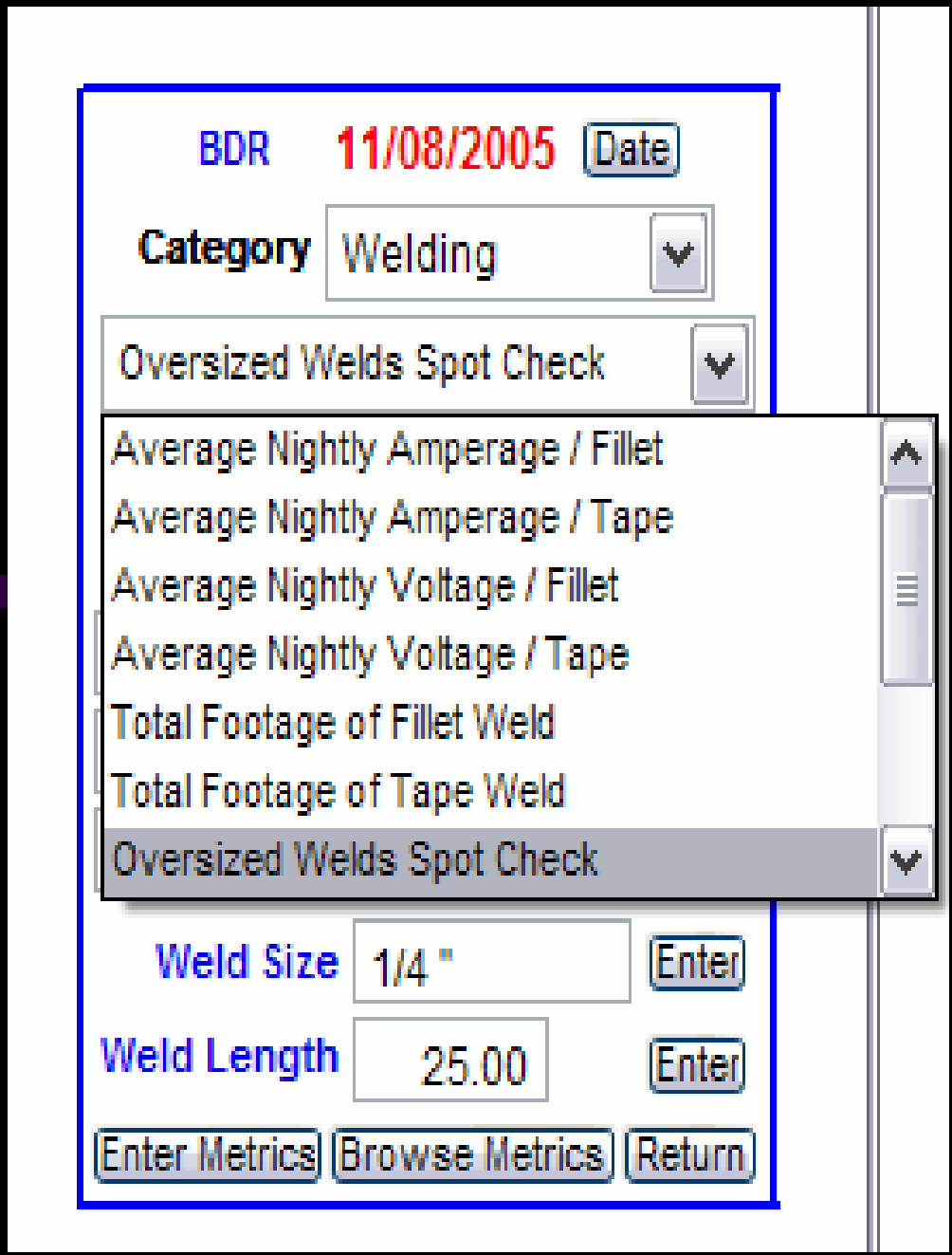
Weld Length →



Select Category For Metric



Weld Types Drop Down Menu

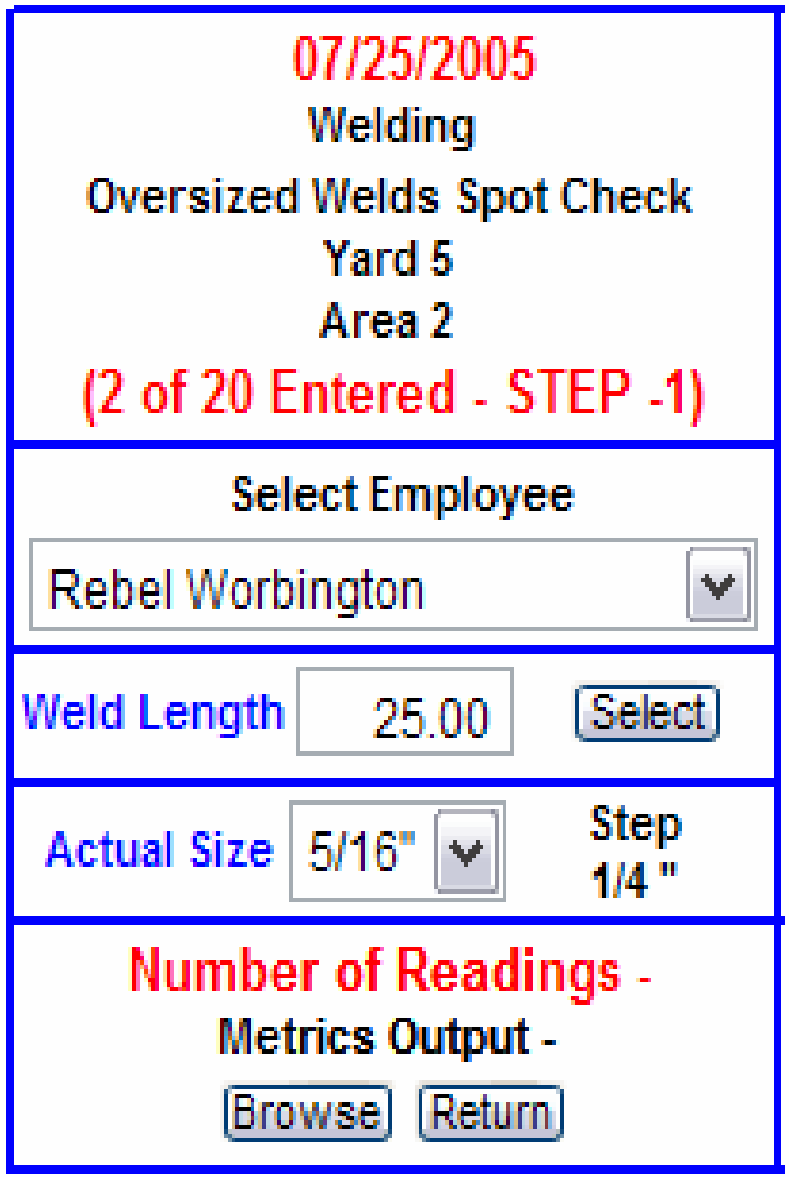


Weld Information & Location

Select Welder

Step Identifies Weld Length or Drop Down & Select Length

Drop Down & Select Actual Size



Reporting

Date Range

Data Range That Is On Palm

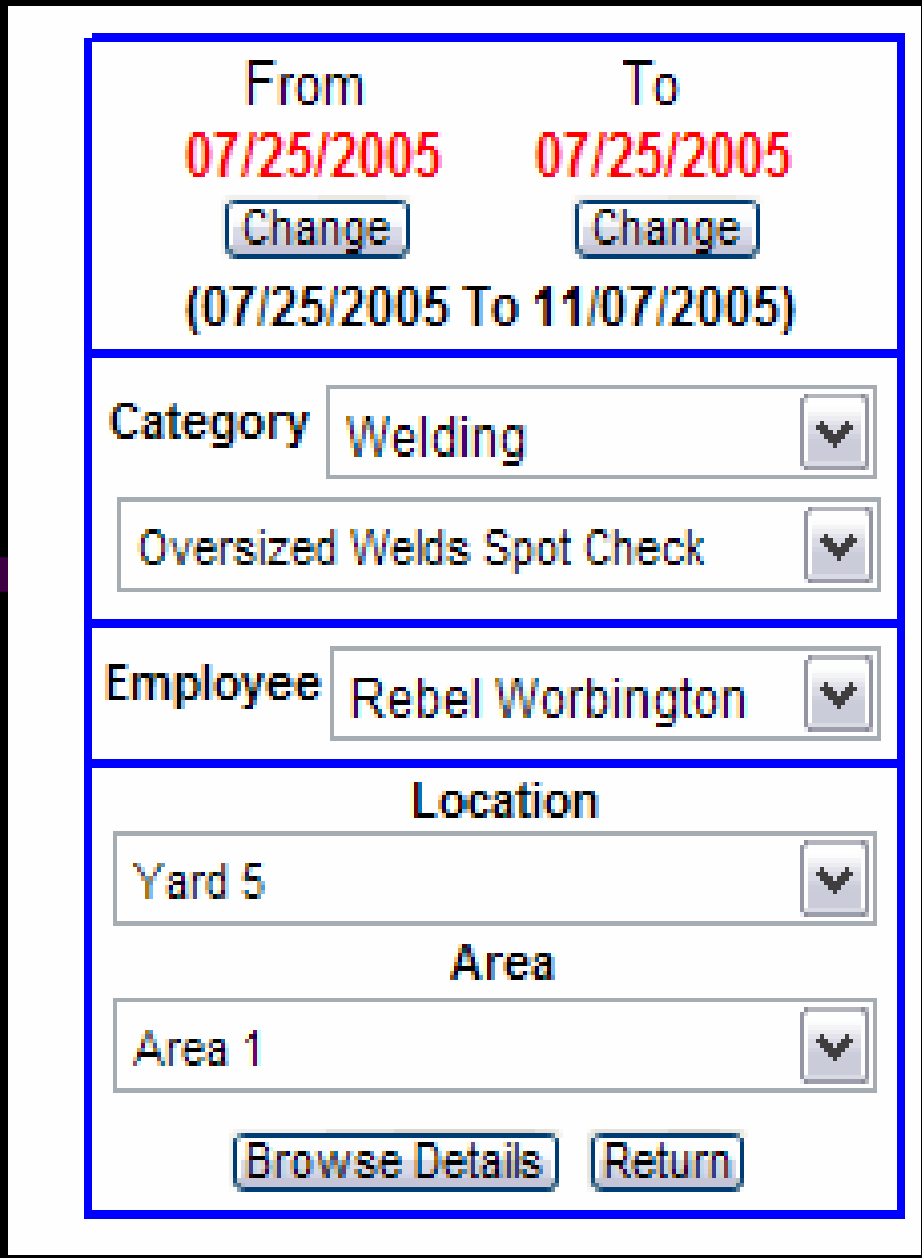
Category

Type Weld

By Employee

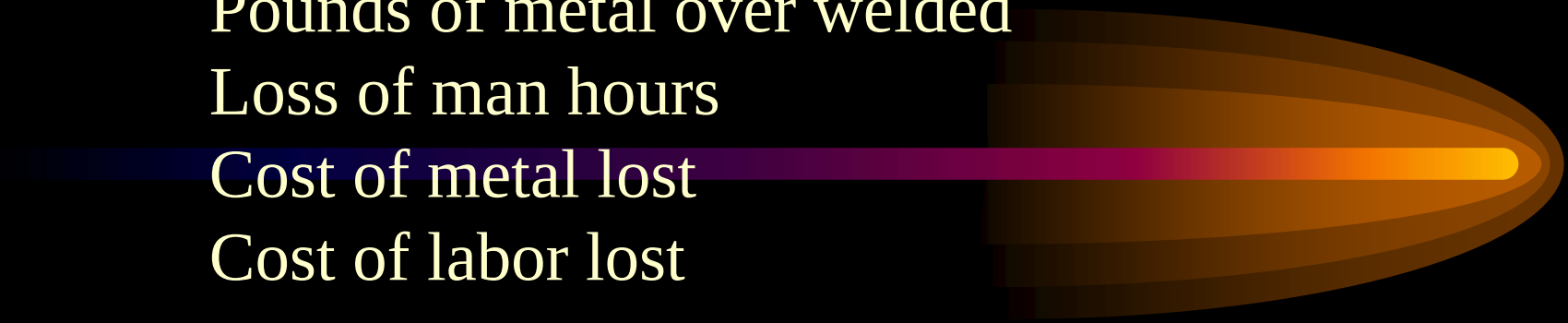
Location

Area



The system will automatically calculate by Welder:

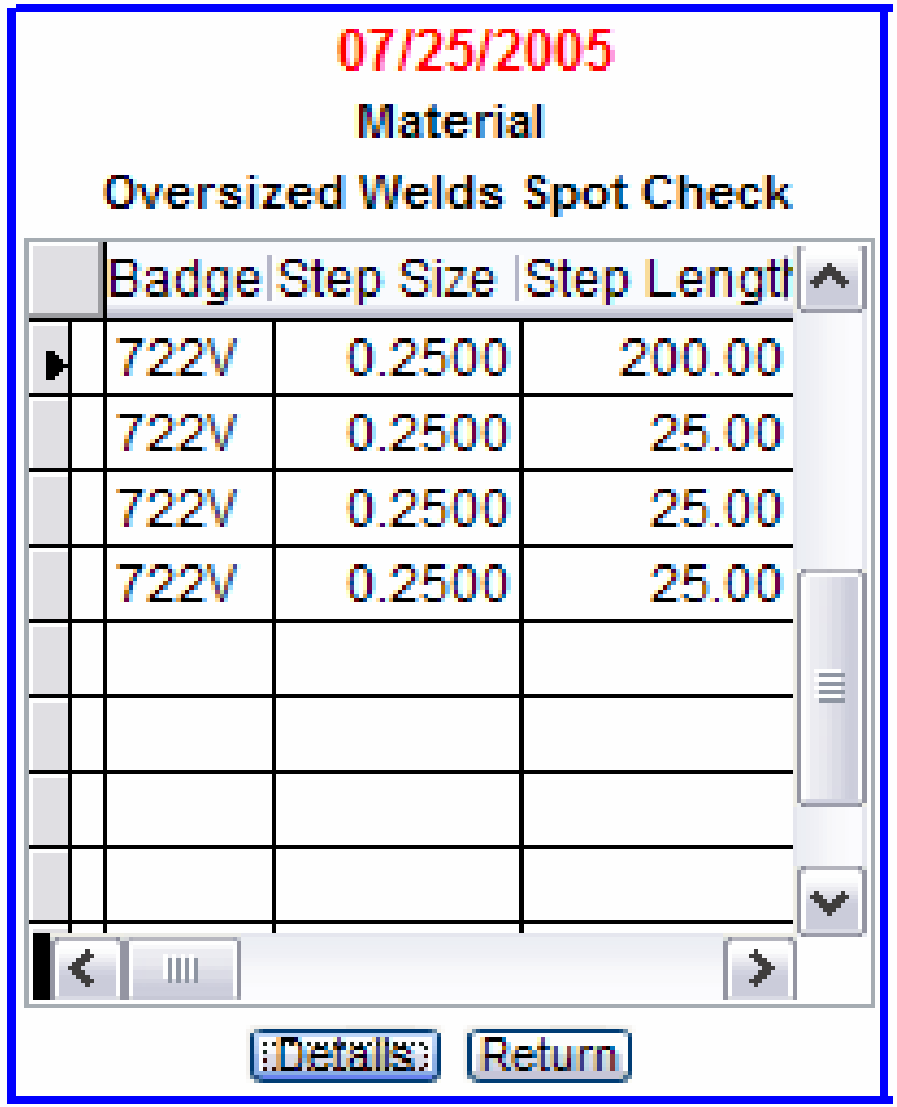
- Number of feet over welded
- Pounds of metal over welded
- Loss of man hours
- Cost of metal lost
- Cost of labor lost



This information can be displayed on PDA or in a report by:

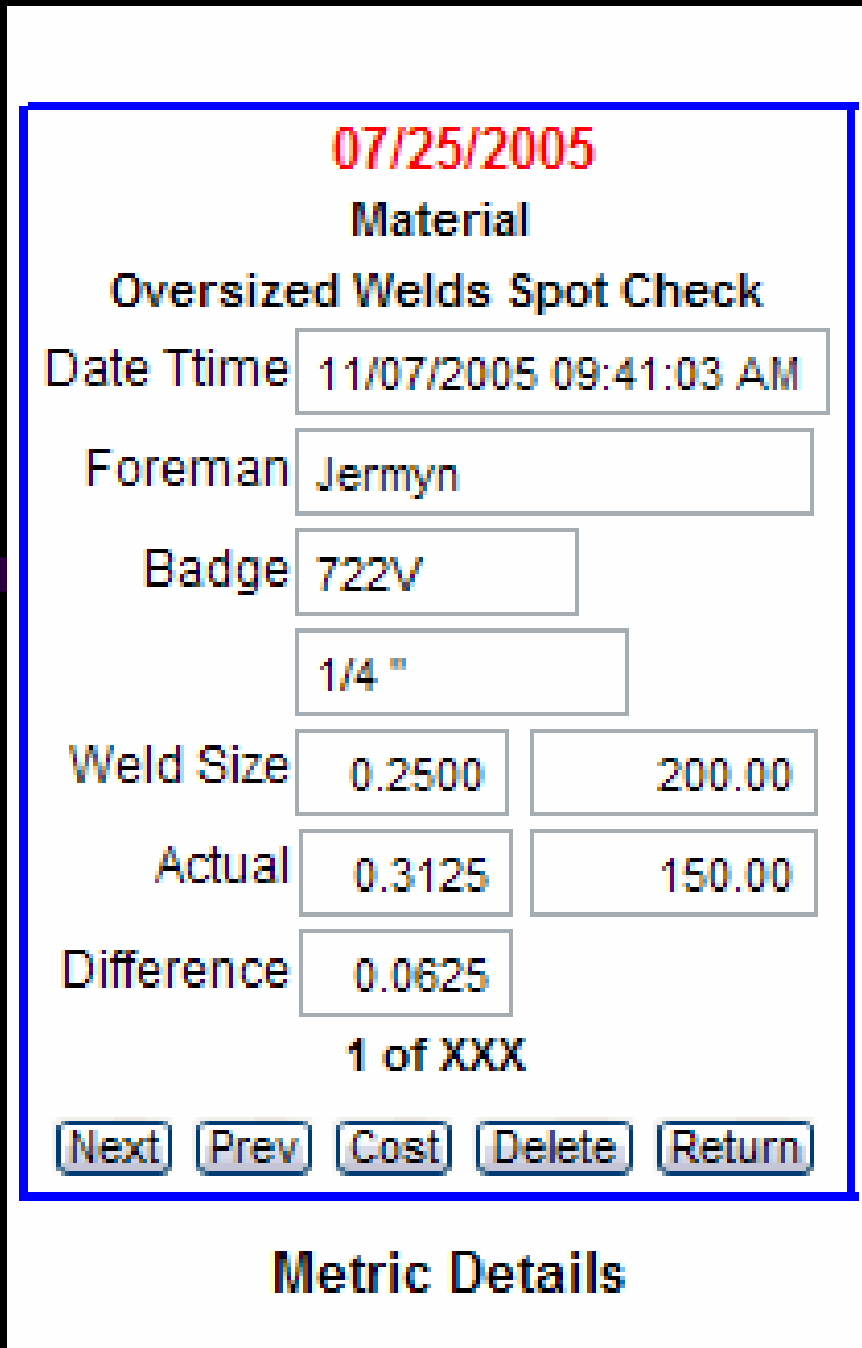
- Job
- Area
- Foreman
- Location
- Employee

Browse Details
In
Various Formats



Metric Details

View Details

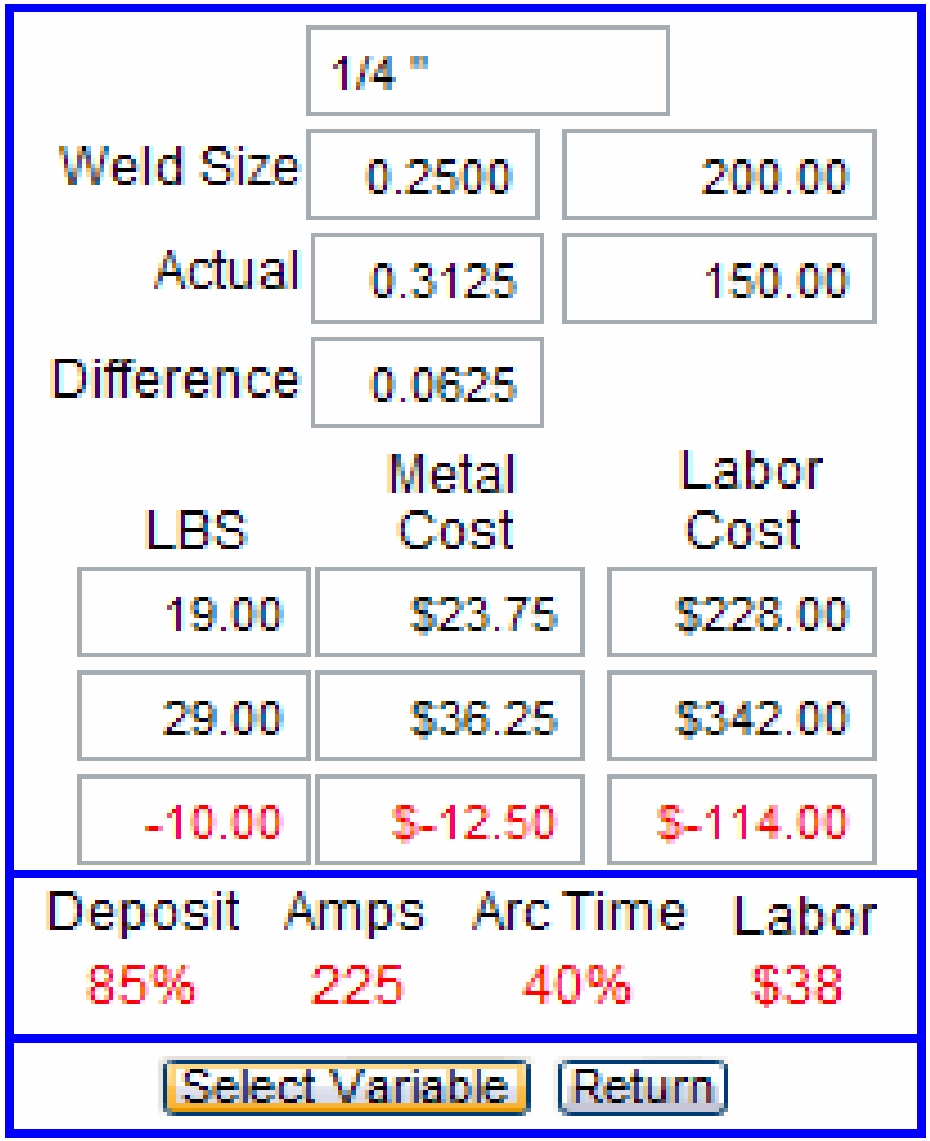


View Cost Details or Summary

Budgeted →

Actual →

Delta →



Metric Details

Using Tables

The following table is an example of using a spreadsheet to perform upfront “what ifs” to determine the overall gain/loss of a metric. This helps to justify if a particular metric should be considered to be automated.

Every operation may have a metric (welding, fitting, fabrication, bending, cutting….) designed with it’s own unique calculations in order to determine status or costs.

Employees are trained to research, create, and use tools like this example to manually sample your daily operations prior to implementing the metric on the palm.

In this example we like to view the cost of a single operation and the gain/loss if not properly performed. We then like to determine how much this metric could cost in a daily, weekly, monthly, or yearly basis if gone unchecked.

View & Calibrate Table

Over Weld Metric Example

Number of Welders	1	
Average No. of Daily Welds	20	
Average Weld Length	10	
Audit Percentage	100%	20
Bad Welds Found	5%	1
Metal Cost	$1.25	
Labor Cost Per Hours (loaded)	$42.00	
Pounds Per Hour of Metal Deposit	8.2	

Size Chart			
1/16"	0.0625	1/4"	0.25
5/16"	0.0781	5/16"	0.3125
3/32"	0.0937	3/8"	0.375
1/8"	0.125	1/2"	0.5
5/32"	0.1562	3/4"	0.75
3/16"	0.1875		

One Weld

Length	10		
Weld Size	0.1875	3/16	
Actual	0.2500	1/4	
Diff.	0.0625	1/16	

Pounds To Deposit	Wire To Purchase	Metal Cost	LBS Deposited Per Hour	Labor Cost
0.6	0.7	$0.88	0.16	$6.79
1.1	1.2	$1.56	0.3	$14.21
-0.5	-0.5	-$0.68	-0.2	-$7.42

Deposition Eff. Rate	Machine Amps	Arc Time	Labor Unit Rate
85%	250	45%	$42.00

Multiple Welds

Length	10		
Weld Size	0.1875	3/16	
Actual	0.2500	1/4	
Diff.	0.0625	1/16	

Pounds To Deposit	Wire To Purchase	Metal Cost	LBS Deposited Per Hour	Labor Cost
0.6	0.7	$0.88	0.16	$6.79
1.1	1.2	$1.56	0.3	$14.21
-0.5	-0.5	-$0.68	-0.2	-$7.42

Deposition Eff. Rate	Machine Amps	Arc Time
85%	250	45%

45% Arc Time is equal to 27 minutes per hour, or 3 hours and 36 minutes a work day
At 250 Amps, depositing 8.2 pounds per hour, 137.6 feet welded in an hour at a 100% arc time.
An 8 hour day, he can weld 1100 feet. Now with a 45% arc time, he can weld 495.3 feet a day.
Round this off to 500 feet a day is the reason Jackie choose this as the baseline.

Week	Month	Year
-$37.08	-$148.33	-$1,779.92

Deposition Rate — Based on wire diameter, amperage, electrical stickout, gas

Machine Amps

Another Example Using Tables

In the next example we used a spreadsheet to sample over welding, and the costs associated by having just 20 welders on staff.

Keep in mind that welders traditionally think that a little over welding makes for a better weld. However, we found out that if everyone over welds just a little can cost a company millions per year. This may be true for performing all operations within the manufacturing community.

We designed this table to calculate a single weld, and a table with multiple welds and employees. This enables us to calibrate the single weld, and then enter in the left table different variables such as total employees, average of daily welds, number of welds audited, and the number of bad welds found.

You may also change other variables such as labor costs, material deposit costs, and welding variables such as efficiency rate, machine amps, and arc time depending on the work station and operation that you are monitoring.

This right table shows that if 5% of your employees are over welding by just 1/16, and had just 5% of over welds in a year could cost thousands and hundreds of thousands of lost materials, man hours, and productivity.

This is why you need to track operations. You need to know where your potential and real losses are coming from.

If you are not sampling your operations, then you will never know.

View Cost Details or Summary

Over Weld Metric Example

Number of Welders	20	
Average No. of Daily Welds	20	
Average Weld Length	10	
Audit Percentage	100%	400
Bad Welds Found	5%	20
Metal Cost	$1.25	
Labor Cost Per Hours (loaded)	$42.00	
Pounds Per Hour of Metal Deposit	8.2	

Size Chart			
1/16"	0.0625	1/4"	0.25
5/16"	0.0781	5/16"	0.3125
3/32"	0.0937	3/8"	0.375
1/8"	0.125	1/2"	0.5
5/32"	0.1562	3/4"	0.75
3/16"	0.1875		

One Weld

Length	10		
Weld Size	0.1875	3/16	
Actual	0.2500	1/4	
Diff.	0.0625	1/16	

Pounds To Deposit	Wire To Purchase	Metal Cost	LBS Deposited Per Hour	Labor Cost
0.6	0.7	$0.88	0.16	$6.79
1.1	1.2	$1.56	0.3	$14.21
-0.5	-0.5	-$0.68	-0.2	-$7.42

Deposition Eff. Rate	Machine Amps	Arc Time	Labor Unit Rate
85%	250	45%	$42.00

Multiple Welds

Length	10		
Weld Size	0.1875	3/16	
Actual	0.2500	1/4	
Diff.	0.0625	1/16	

Pounds To Deposit	Wire To Purchase	Metal Cost	LBS Deposited Per Hour	Labor Cost
11.9	14.0	$17.56	64.71	$2,717.84
21.2	25.0	$31.21	135.3	$5,684.36
-9.3	-10.9	-$13.66	-70.6	-$2,966.53

Deposition Eff. Rate	Machine Amps	Arc Time
85%	250	45%

45% Arc Time is equal to 27 minutes per hour, or 3 hours and 36 minutes a work day
At 250 Amps, depositing 8.2 pounds per hour, 137.6 feet welded in an hour at a 100% arc time.
An 8 hour day, he can weld 1100 feet. Now with a 45% arc time, he can weld 495.3 feet a day.
Round this off to 500 feet a day is the reason Jackie choose this as the baseline.

Week	Month	Year
-$14,832.63	-$59,330.52	-$711,966.28

Far Reaching Metric Software Benefits

- Software Can Be Used For Collecting Other Metrics:
  - Paint
  - Pipe
  - Electrical
  - For QA Audits
  - Etc.
- Plug and Play Software With Training Aids
- Training Implications

  Videos and pictures of techniques, on-line training aids