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BTI *ASC's Building the Industry Program*

Cost Model User Guide

BACKGROUND

This cost model is a comparative cost model to compare the cost of joining components or their sub-assemblies together by adhesives, mechanical fasteners, or welding.

The model is designed to capture costs in a production line environment, but can be used for other production environments. Once the user has a basic understanding of how the model works, it is somewhat intuitive as to how to manipulate the definition of bonding application to capture different non-production environments, such as on site construction.

The model can be used at either the strategic level to understand the cost of a particular technique throughout an industry application, or at the customer level, as a way to show how adhesives compare to either mechanical fastening or welding in use now. It is not meant to be a salesperson tool due to its complexity.

The real attraction of this model is it forces manufacturers and customers to examine and think through cost drivers of competing joining/bonding processes, something that few customers currently measure or understand.

HOW IT WORKS

The model uses the user inputs from the *Input Table* worksheet and calculates a cost summary displayed on the *Cost Summary* worksheet. The cost summary is based on user inputs and underlying assumptions from the *Assumption Table* worksheet.



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HOW TO USE

This workbook is made up of four worksheets, *Read Me, Input Table, Assumption Table, and Cost Summary*.

Each of worksheets, *Input Table, Assumption Table, and Cost Summary* have sections in this guide that describe their contents. Additionally, the sheets have comments in column heading to help guide the user of the model.

*For the Input Table sheet to work properly the user **must allow macros** for the buttons to work properly.*

To check Excel's macro security level, go to Tools > Macro > Security to make sure the "Security Level" is set to "Medium". If security is set to "High" Excel will disable the macros automatically when launched. Make the appropriate changes if necessary and relaunch the model.

Users inputs in brief:

Click the appropriate button for the type of joining technique used: For example "Adhesive & Sealant view" for adhesive and sealant bonding. This gives you the appropriate columns on the "*Input Table*" that need to be filled in.

Columns have comments in the title cells to explain what user input is needed and/or what the column calculates

Column titles in "**RED**" lettering are calculated, and may or may not be overridden. See comment notes in the columns for guidance.



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Input Table Contents (**sheet not protected**)

The **Input Table** is engine that drives the cost model. It is made up of numerous input columns that the user must input data into. These columns are segmented into following sections:

Descriptive and number/type of joining applications: Columns A through L

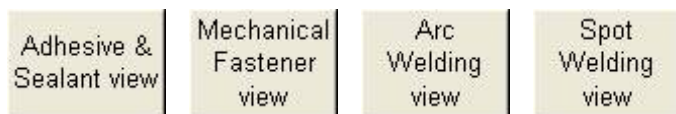
Part/Surface preparation: Columns M through AA

Joining Process: Columns AB through CY

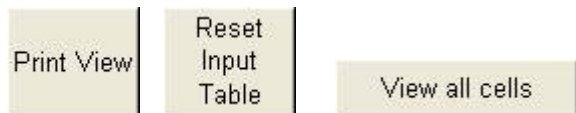
Other Costs: Columns CZ through DH

The columns that appear depend upon which button is selected.

Buttons:



The above buttons change the column views to reveal the appropriate input columns to input data into. Although it may appear that clicking a button does nothing, scrolling across the columns will show different columns depending upon which view is chosen.



The “Print View” button shows all of the input columns for all joining techniques. It is also the only view formatted for printing.

“Reset Input Table” will erase all of user input data into the sheet. (**Use with *extreme caution* since all data input will be lost if not saved into another file.**)

“View all cells” shows all the cells in the sheet including hidden cells. This should only be used if a user is planning to modify the model, or wants to look at the entire contents of the worksheet to understand how the model works.



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Descriptive and number/type of joining applications: Columns A through L

Joining Technique	Segment	How to use this spreadsheet	Sub--Segment	Component	Joining / Bonding Application
	Name	NAICS No.	Name	Component description	description

Joining Technique is a drop down box with 3 choices, Adhesives & Sealants, Fasteners, and Welding (**Required**)
Segment is a text description to identify the broad market, such as Construction or Transportation
NAICS No. is a text input for using the North American Industrial Classification System if desired
Sub-Segment is a user input text description of a narrow market, such as Automotive Lighting
Component is a user input text description of the component being bonded, such as a headlamp assembly
Joining Application is a description of what exactly is being joined, such as 2x4 walls studs to header boards and floor

Number of joining applications for production line modeled	Number of joining applications (industry wide)	Substrate Type		Performance Requirements
per Year	per Year	Adherend 1	Adherend 2	(Specification No.)/ Test Method and/or Minimum Requirement

Number of joining applications for production line modeled user must input a number joining applications (**Required**)
Number of joining applications (industry wide) is used to project costs on an industry wide basis (assumed to be equal to Number of joining applications for production line modeled, unless the user changes it)
Substrate Type is for user input text to describe the type of substrates are being joined, such as polycarbonate to polycarbonate
Performance Requirements is for user input text to describe any specifications that must be met in the joining application



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Part/Surface preparation: Columns M through AA

Part Preparation for Joining				Surface Preparation Joining										
Cutting	Folding	Shaping	Forming	Cleaning	Coating removal	Annealing	Surface Priming	Corona	Flame Treatment	Drilling	Grinding	Other (\$ per bond)	How Many Laborers	Surface Preparation Cycle Time (seconds)

For columns Cutting through Grinding place and “x” in any cell to signify any process that occurs in part or surface prep. Additionally, there is a column to put in Other (\$ per bond) which should be used instead if there is a good cost estimate instead of the “x” since these processes can vary tremendously in cost depending upon any number of variable in joining two components


How Many Laborers is a user input to capture the number of laborers needed for the entire part and surface preparation.

Surface Preparation Cycle Time (seconds) is a user input to capture the amount of time for entire part and surface preparation in seconds

Joining Process: Columns AB through CY, described by joining method, i.e. adhesives, mechanical, welding

ADHESIVE INPUT COLUMNS



Click the  button to see the appropriate input columns



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Adhesive Joining Processes				
Adhesive	Sealant	Adhesive/Sealant		
Application	Application	Technology	Formulation	% Solids

Adhesive and the Sealant Application columns are simply a yes/no drop down to record if this is an adhesive and/or sealant application
Technology is a drop down box, containing the following technologies for structural adhesives/sealants: **(Required)**

Anaerobic MS Polymer Bismaleimide Phenolic Block Copolymer Polysulfide Butyl Silicone Cyanoacrylate Urethane Elastomeric PSA Tape Epoxy Hi- Strength PSA Tape Methacrylate

Formulation is a drop down box, containing the following formulations for structural adhesives/sealants: **(Required)**

1PT LS Solvent 1PT HS Solvent 1PT Water 2PT Water Rad Cure 2PT LS Solvent 2PT HS Solvent 2PT HS Solvent Foam Dbl Faced Hot Melt

% Solids is a calculated column from a table in the Assumption Table Sheet. It is dependent upon the user input in Formulation column.
This number can be overridden by the user.



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Adhesive Joining Processes						
Geometry (for use to calculate grams if unknown)						
Bead Diameter (inches)	cc/inch	Bead (or Tape) Length (inches)	Width of Tape (inches)	or Grams of adhesive per bond	\$/gram for adhesive / sealant (or \$/inch ² for tape)	Specific Gravity of Adhesive (gr/cc)

Bead Diameter (inches) is a drop down box to choose the diameter of the bead

cc/inch is a calculated value based upon the bead diameter and a table from the Assumption Table Sheet

Bead (or Tape) Length (inches) is a user input for the sum of all bead lengths for the bonding application

Width of Tape (inches) only needs to be filled in if tape is used

or Grams of adhesive per bond is a calculated column based on a table from the Assumption Table worksheet, but can be input directly if known (**Required**)

\$/gram for adhesive / sealant (or \$/inch² for tape) is a calculated field, but since the adhesive prices per pound in the Assumption Table worksheet have been removed as requested by the ASC, this will need to be filled in manually, or prices can be input into the [Adhesives/ Sealants Pricing \(\\$/lb\) \(\\$/yd²\)](#) sheet in the Assumption Table worksheet for the calculated \$/gram to work.

(454 grams = 1 pound)

Specific Gravity of Adhesive (gr/cc) is a calculated field based on the **Technology** input column and [Specific Gravity](#) assumption table.



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Post Joining Processes				
Process	Cycle time required for post bond process (seconds)	Additional floor space (ft2) required	Curing & Drying Time (seconds)	How Many Laborers

Process Drop down box to choose among adhesive post joining processes:

- | | | | | | |
|--|----------------------------|----------|-------------------|--------------|-----------------------------------|
| Application of moisture for cure is applicable | Autoclave | Clamping | Induction heating | Oven heating | Post application heating fixtures |
| | Radiant heat (lamps, etc.) | | | | |
| Pressing | | Rad Cure | Vacuum processing | Vapor cure | |

Cycle time required for post bond process (seconds) Includes the time from when the parts arrive for post processing until joining post processing is completed

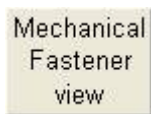
Other columns capture additional costs for floor space and labor.



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MECHANICAL FASTENER INPUT COLUMNS



Click the  button to see the appropriate input columns

Mechanical Fastening Process			
Type of mech. Fastener (A)	Number of (A) used	Relative Cost of (A) \$/part	Cost of (A) \$/part

Type of mech. Fastener (A,B,C, or D) Choose from the drop down box

Number of (A, B, C, or D) Input the number of the type of mechanical fastener chosen in the 1st column


Relative Cost of (A) \$/part Choose from High, Medium, or Low.

Cost of (A) \$/part This is a calculated number based on the **Relative Cost of (A) \$/part** and [Mechanical Fastener Pricing \(per unit\)](#) from the Assumption Table sheet

There are 4 sets of these inputs labeled, A through D. This is to allow multiple (up to four) types of mechanical fasteners to be recorded in the joining operation. For example, bolts for one type (A), and nuts for another (B) both of which are needed for one assembly.

ARC WELDING INPUT COLUMNS



Click the  button to see the appropriate input columns



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Arc Welding Processes							
		Typical Values for Manual Arc Welding for Steel			Option #1 for cost of materials		
Welding Method	Arc time (seconds)	Deposition Efficiency for Welding Processes and Filler Metals	Operator factor	Material Costs (\$/lb)	Electrode (Type)	Volume of deposited material for welding process (in. ³)	Weight of deposited material (lb.)

Welding Method Chose from the following:

Shielded Flux Gas
Spot Metal Core Metal Submerged

Arc time (seconds) Input the “arc on” time for arc welding

The next three columns give a guide to what the deposition efficiency, operator factor (welding time/total cycle time), and material cost typically is for the welding method chosen.

Choose only one of the three methods to calculate the cost of materials

Option # 1 for cost of materials:

Electrode (Type) Drop down box with the following types of electrodes to choose from:

Carbon Stainless Copper Aluminum Magnesium Titanium
N/A Steel Steel Alloys Nickel Alloys Alloys Alloys Alloys

Volume of deposited material for welding process (in.3) Input the amount of deposited material in cubic inches

Weight of deposited material (lb.) Calculated based on electrode type and [Approximate Density for Some Common Engineering Alloys](#) from the Assumption Table worksheet



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Arc Welding Processes			
Option #2 for cost of materials			
Bare electrode wire (American Welding Society classifications)	Diameter in.	Bare electrode wire (American Welding Society classifications) lb./in.	Wire feed speed (in./min.)

Bare electrode wire (American Welding Society classifications) is a drop down box with a list of a number of welding wire classifications to choose from

Diameter in. Drop down box to choose from

Bare electrode wire (American Welding Society classifications) lb./in. Calculated based on previous 2 column inputs and lb./in. [Bare Electrode Wire of Various American Welding Society classifications](#) from the Assumption Table worksheet



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Arc Welding Processes					
Option #3 (see assumption table for precalculated deposition rates)					
Type of joint (steel only)	thickness in.	size in.	volume (in ³ /per ft. of weld)	weight (lb/ft)	Weld length (in.)

Option # 3 is another alternative to calculate the cost of materials for arc welding. If the type of joint is known as well as thickness, and size, go to the assumption table to see what values are. See [Option #3 Cost of Materials for arc welding](#) to see a list of values to put into these columns.

Weld length (in.) is the only input that needs to be independently generated by the user

Arc Welding Processes			
Use only if gas shielding is required			
Gas flow rate (ft ³ /hr)	Cost of gas required (ft ³)	Gas cost (\$/cubic ft)	Cost of Electrode / deposited material (\$/lb.)

Shielding gas columns are pretty self explanatory. See comments in model itself for further info.



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Cost of Electrode / deposited material (\$/lb.) Referenced from [Avg. price per pound \\$](#) for bare electrode wire in the Assumption Table worksheet

Spot / Resistance Welding Process						
Setup or Changeover costs including overhead (\$)	Average number of weldments produced per setup	Production quantities per cycle	Number of welding work centers	Welding work center overhead rate (\$ per hour)	Direct material cost per weldment (\$)	Cost of small tools and fixtures per weldment (\$)

The five main cost drivers for spot welding are:

- 1) Setup or line changeover costs (captured **Setup or Changeover costs including overhead (\$)**)
- 2) Direct labor costs (captured in columns **How Many Laborers / Operators** and **Joining Process Cycle Time (seconds)**)
- 3) Direct material costs (captured in columns **Direct material cost per weldment (\$)**)
- 4) Cost of small tools/fixtures (captured in columns **Cost of small tools and fixtures per weldment (\$)**)
- 5) Overhead (captured in Other Costs columns in the Input Table worksheet)



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Joining / Fastening Process	
How Many Laborers / Operators	Joining Process Cycle Time (seconds)

These two input columns are turn out to be critical cost drivers in most cases because the labor component of cost is such a high percentage of joining cost compared to capital and material costs: **(Required)**

Other Costs								
Labor Rate \$/hr	Overhead Cost Factor (%) of direct labor cost	Days of inventory for joining type	ft2 required for process including inventory (not including post joining process)	% rework, scrap, returns	Annual Maintenance Cost \$	Annual Equipment Depreciation (Capex) \$	Energy Usage (annual kWh)	Other Costs

Notes in the cost model for each cell explain what is required in each column. See comments in model itself for further info.



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Cost Summary Sheet

Descriptive and number/type of joining applications: Columns A through K

Part/Surface preparation: Columns L through X

These columns mirror as the cells on the input range.

Surface & Part prep		
\$ per prep for joining		
Sum of Part & Surface prep costs	Surface Preparation Cycle Time (seconds)	Surface Preparation Total Labor \$

These columns capture the material and labor cost of surface/part preparation on a per bond basis.



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Joining Processes

Welding

\$ Cost of adhesive / sealant used per bond	\$ Cost of tape used per bond	\$ Cost of mechanical fasteners used per bond	Type	Cost of welding material used per bond (Arc Welding) \$	Manufacturing costs per weldment (Spot Welding) \$	Joining Process Cycle Time (seconds)	Joining Process Labor \$
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\$ Cost of adhesive / sealant used per bond is equal to (grams of adhesive per bond * \$/gram for adhesive / percent solids)

\$ Cost of tape used per bond is equal to (tape length * tape width * price of tape inch²)

\$ Cost of mechanical fasteners used per bond is equal to (number of fasteners A * price of fastener A + number of fastener B * cost of fastener B..... through fastener D)

Cost of welding material used per bond (Arc Welding) \$ is equal to Option 1+ Option 2 + Option 3 or (Wire feed speed (in./min.)* (Arc time (seconds)/60)* Bare electrode wire (American Welding Society classifications) lb./in.* Cost of Electrode / deposited material (\$/lb.)+(Weight of deposited material (lb.)* Cost of Electrode / deposited material (\$/lb.)+(Weld length (in.)* weight (lb/ft)/12)* deposited material (\$/lb.)+ Cost of gas required (ft³)

Manufacturing costs per weldment (Spot Welding) \$ is equal to Number of welding work centers* Welding work center overhead rate (\$ per hour)+ Direct material cost per weldment (\$)+Cost of small tools and fixtures per weldment (\$)+Setup or Changeover costs including overhead (\$)/Average number of weldments produced per setup

Joining Process Labor \$ is equal to Joining Process Cycle Time (seconds)* (Labor Rate \$/hr/3600)

