COMPARING THE COST OF SECURING Sheet Metal Panels

by David D. Archer

One of the more common fastening tasks for OEMs is attaching cover panels to a fabricated frame. In some cases these panels are designed to be removable, but in most cases they are permanently joined or are fastened but not intended to be removed in normal use. In a cost-reduction study we conducted not long ago, we compared the cost of securing sheet metal panels to a welded tubular frame by various methods. We wanted to expand and generalize that study to make it applicable to a wide range of *American Fastener Journal* readers. In this article, we compare the cost of fastening or joining a plain sheet panel using the methods listed in Table 1. These methods are not all-inclusive and were selected because they do not require high levels of capital investment in process or material handling equipment. In these cases, comparative costing tends to be a function of calculating return on capital investment on equipment whose implementation is too specialized to be considered in an article on costing guidelines.

ASSUMPTIONS

As a practical necessity, we will need to make several assumptions regarding the component configuration and assembly conditionson which the estimates are based. Because these assumptions will have a significant impact on the cost estimates generated, the results of this study should be thought of as only a starting point for process selection. These assumptions are summarized in Table 2.

COMPARATIVE BASIS

Before a cost comparison can be undertaken, a fundamental aspect of joint requirements must also be assumed. For each of the joining and fastening methods selected, the basis for determining the coverage or pitch needs to be determined. In other words, is the distance between rivets or the percentage full perimeter a bead of adhesive is applied established based on the need to simply hold the panel in place without objectionable gaps, or is it on a minimum strength requirement? We felt that providing some indication of equivalent strength would be of value and based the estimates on equivalent shear strength.

When used to secure thin panels, it is unlikely that fastening and joining methods will be capable of achieving their full shear or tensile strength before joint failure. This is because deformation of the sheet material either causes the sheet to pull out from under the fastener head, or it puts a bending load on the fastener due to eccentric loading from the inboard side of the panel causing sheet bending. This effect reduces actual performance of adhesives as well because it causes the bond to be loading in peel rather than pure shear or tension. We selected shear rather than tensile loading as the basis for comparison as it is probably more common case, and actual loading is closer

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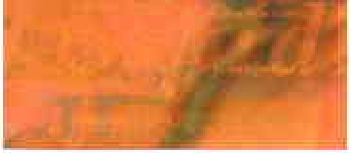

TABLE 1. Attachment Method Types and Sizes

METHOD	TYPE	SIZE	COMMENTS
Drill Screw	Hex Washer Head	#10-24 x1/2"	#3 point, zinc-plated
Blind Rivet	Steel Body, Steel Shank	3/16" x 1/4"	Dome head
Epoxy Adhesive	Two-part room temperature cure	200 ml dual cartridge	Mixing tube incl. in material cost
Tack Weld	GMAW (MIG)	0.045" dia. solid	33 lb. spool

TABLE 2. Component and Assembly Assumptions

1. The panel is manipulated by one person and will be joined to the frame in the horizontal position.
2. Sheet and frame are 16 ga and 12 ga, respectively 0.060" (1.5 mm) and 0.105" (2.7 mm).
3. No clamping or special tooling will be required to locate the panel or maintain its position.
4. Tacks are welded manually.
5. Weld strength is assumed to be equal to the base metal. Frame and cover sheet tensile strength is 50 ksi (344 Mpa).
6. Epoxy will be applied manually with a cartridge and mixing tube.
7. Epoxy bead width at application is 3/16".
8. To estimate epoxy bond line width after assembly, an average bond line thickness must be estimated. For a non-clamped fabrication, that estimated thickness is 0.50.
9. Prior to bonding, both the cover and frame surfaces will be manually wiped clean with solvent.
10. The time to clean the mating surfaces before bonding is the same whether the entire perimeter is bonded or the adhesive is applied intermittently. In all cases, the entire perimeter is cleaned.
11. The drill screw will be driven in a magnetic bit by an electric or air tool capable of at least 1800 rpm during drilling.
12. Rivet holes are assumed to be pre-punched in the panel. The time for the operator to match drill the mating holes with an electric or air tool, capable of at least 1800 rpm, is part of the assembly time.
13. Blind rivets will be installed manually with a pneumatic rivet gun.
14. All securing methods were applied before final painting operations.
15. All operations included a setup time that assumed all tools and fasteners were in the immediate area. Setup time was estimated at between 4 to 10 minutes.
16. Fastener and metal shear strength is assumed to be 60% of tensile strength. Rivet and adhesive shear strength is taken from published data.

TABLE 3. Relative Shear Strength

	SHEAR STRENGTH, LB	NORMALIZED	EQUIV. QTY. TO EPOXY
Drill Screw (each)	630	0.70	0.82
Blind Rivet (each)	590	0.66	0.87
Epoxy (per inch)	515	0.57	1.00
Tack Weld (per tack)	900	1.00	0.57

Two different scenarios were compared:

1. Vary the density of the securing methods to yield varying degrees of shear strength for a given panel size. Based on the percentage of the panel perimeter bonded, strength levels were 25%, 50% and 100%. The panel size was assumed to be 24" x 24".

2. Vary the size of the panel while maintaining the same shear strength per foot of panel length. The panel sizes used were 124 x 124, 244 x 244 and 484 x 484. A 50% bond was assumed in each case.

TABLE 4. Total Labor Time (minutes)

	COVERAGE @ 24" X 24"			SIZE @ 50%		
	25%	50%	100%	12 x 12	24 x 24	48 x 48
Drill Screw (each)	7.8	11.3	18.1	7.3	11.3	18.8
Blind Rivet (each)	10.3	14.1	21.8	10.1	14.1	22.6
Epoxy (per inch)	16.2	16.2	16.2	13.3	16.2	22.2
Tack Weld (per tack)	12.6	14.0	17.0	12.6	14.0	17.4

to what would be expected in theory in comparison to assumption of tensile loading. In order to minimize the over-estimate of each method's capacity, we selected fastener sizes that were on the small end of the range of what might be used for these applications.

Based on the assumptions made in Table 2, the absolute and relative shear strength of the securing methods are shown in Table 3. The column at right shows the quantity of fasteners or tack welds that would be needed to provide the same shear strength for each inch of bond line. Because adhesive isn't applied on a unit basis, it was decided to use the length of the adhesive bond line as the basis to calculate the quantity of welds or fasteners required to achieve equivalent strength.

LABOR ESTIMATES

Based on the assumptions in Table 2 and the relative shear strength of Table 3, the estimated labor required to secure the panels in the two scenarios presented are summarized in Table 4.

MATERIAL COST

The price paid for hardware, adhesive or consumables is, of course, highly dependent on the annual volume required. For the purpose of this type of comparative study, it is probably more important to be accurate in relative costing as it is in absolute terms. For this reason, all materials were priced at the same national industrial supply company, so the markup is kept consistent. Our experience is that a good estimate for what the low- to mid-volume manufacturer might pay for hardware is to take the retail price from an industrial supply house and discount it by 20%. Using that formula resulted in the material costs shown in Table 5.

RESULTS

TABLE 5. Material Cost

Drill Screw (each)	$0.054
Blind Rivet (each)	$0.032
Epoxy (per inch)	$0.029
Tack Weld (per tack)	$0.000

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TABLE 6. Cost Summary

	% PERIMETER BONDED @ 24" x 24" SIZE			SIZE @ 50% BONDED		
MATERIAL COST	25%	50%	100%	12 x 12	24 x 24	48 x 48
Drill Screw (each)	$1.02	$2.04	$4.09	$0.98	$2.04	$4.18
Blind Rivet (each)	0.64	1.28	2.56	0.61	1.28	2.62
Epoxy (per inch)	0.66	1.32	2.64	0.63	1.32	2.69
Tack Weld (per tack)	0.00	0.01	0.01	0.00	0.01	0.01
LABOR COST @ $35/HR.						
	% PERIMETER BONDED @ 24" x 24" SIZE			SIZE @ 50% BONDED		
	25%	50%	100%	12 x 12	24 x 24	48 x 48
Drill Screw	$4.57	$6.59	$10.53	$4.28	$6.59	$10.94
Blind Rivet	6.01	8.25	12.73	5.89	8.25	13.16
Epoxy	9.47	9.47	9.47	7.74	9.47	12.94
Tack Weld	7.38	8.19	9.89	7.36	8.19	10.16
TOTAL COST						
	% PERIMETER BONDED @ 24" x 24" SIZE			SIZE @ 50% BONDED		
	25%	50%	100%	12 x 12	24 x 24	48 x 48
Drill Screw	$5.59	$8.63	$14.62	$5.26	$8.63	$15.12
Blind Rivet	6.65	9.53	15.29	6.50	9.53	15.78
Epoxy	10.13	10.79	12.11	8.37	10.79	15.64
Tack Weld	7.38	8.20	9.90	7.36	8.20	10.18

TABLE 7. Quantity Required

	COVERAGE @ 24" X 24"			SIZE @ 50%		
	25%	50%	100%	12 x 12	24 x 24	48 x 48
Drill Screw (each)	19	38	75	18	38	77
Blind Rivet (each)	20	40	80	19	40	82
Epoxy (per inch)	23	46	92	22	46	94
Tack Weld (per tack)	14	26	53	13	26	54

FIGURE 1. Cost for Equivalent Shear Strength – 24" x 24" Panel

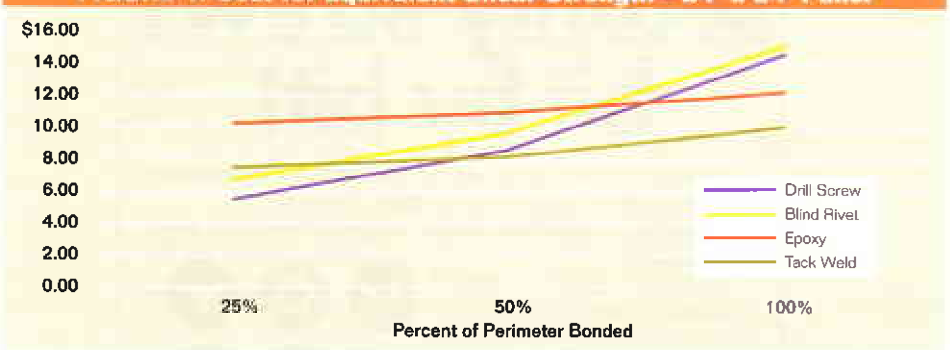
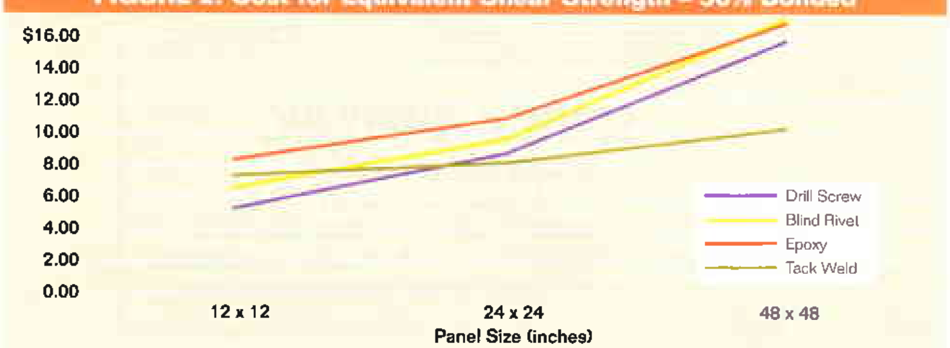


FIGURE 2. Cost for Equivalent Shear Strength – 50% Bonded



We applied a $35/hr. labor rate to time estimates in Table 4 and extended the material cost by the required quantities. The tabular cost summaries are shown in Table 6 and graphed in Figure 1 and Figure 2.

DISCUSSION OF RESULTS

As seen when comparing Figure 1 and Figure 2, the total costs of the two scenarios are very similar because the quantities required are very similar (25% of the perimeter of a 24" x 24" panel is very similar to 50% of a 12" x 12" panel). The epoxy joint does not behave in the same manner because the labor required to prep the panel in the first scenario was the same in all three cases. An important point should be made regarding the equivalent strength assumption. This assumption results in fastener counts higher than would ordinarily be used—up to 82 per panel, as shown in Table 7. Even so, in most cases the fastened joints were more cost-effective due to the higher setup and cleaning cost of adhesives. Had #12 drill screws and 1/4" rivets been used, the fastening costs would have been relatively lower still. However, this also points out that bonded joints can achieve very high strength relative to fastened or tack welded joints when they are utilized as intended, with 100% bond coverage. When this level of strength is actually required, a bonded planar joint will generally be more cost-effective than a fastened joint. In fact, if cleaning wasn't included, the 24" x 24" 100% bonded joint would have had a lower cost than the tack welded joint. ■