Report on Proposed Standards for Sheet Steel Structural Welding

Omer W. B. Blodgett

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In January of 1975, the AWS Structural Welding Committee set up a Task Group, now known as Subcommittee 11, to investigate the problem of sheet steel welding and to develop a proposed set of standards. Since then this group has contacted more than 15 companies and engineers with experience in structural sheet steel welding and has done extensive research to come up with an AWS code accepted by the full committee in the fall of 1976.

Special recognition has been given to the contribution made by Cornell University. The Cornell work is used substantially to validate the conclusions reached about proposed standards.

The work of the Task Group (Subcommittee 11) started out with the recognition that:

1. Sheet steel decking, roofing, and other structural units have been welded in the field for many years with varying degrees of success.

2. Many attempts have been made in the past to set up welding and inspection standards, but these have never been correlated and integrated into a universally applicable system.

3. Numerous tests have been made on sheet steel welds, but the main conclusion from such tests has been that low joint strengths will result when welds are improperly made.

4. Proper welding procedures should be developed that will consistently give good welds.

If proper procedures were to be developed, the Subcommittee would have to investigate the configuration of weld joints; would have to determine under what condition good welds could be made; would have to develop formulas for estimating allowable strengths; and would have to test specimen welds to determine their actual strengths.

A starting point was defining the types of joints used in sheet steel welding and standardizing on a nomenclature. See Figure 1.

Early in the study, the Subcommittee found that past efforts to bring order to sheet steel welding had been frustrated by lack of knowledge on how to make good welds. Data from prior testing programs were often so scattered that the only conclusion reached was the obvious one that low weld-joint strength will result when welds are improperly made. Major tasks were to determine when sheet steel welding is feasible, under what conditions good welds can be made, the development of proposed procedures, and, finally, the testing of welds made with the proposed procedures. Fortunately, the Subcommittee was able to draw from past research to minimize the effort.

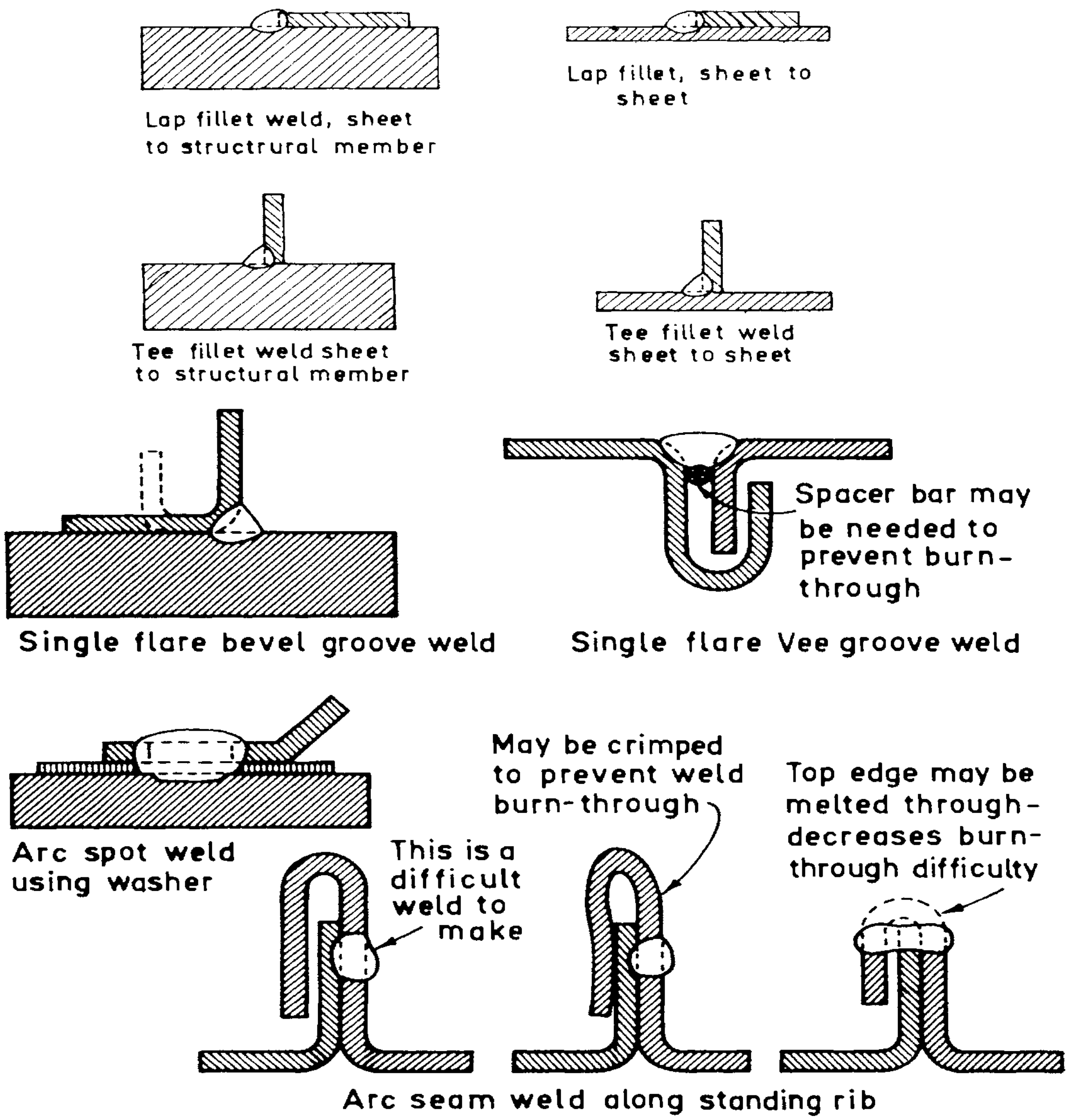

Lap fillet weld, sheet to structrural member
Lap fillet, sheet to sheet
Tee fillet weld sheet to structural member
Tee fillet weld sheet to sheet
Spacer bar may be needed to prevent burn-through
Single flare bevel groove weld
Single flare Vee groove weld
Arc spot weld using washer
This is a difficult weld to make
May be crimped to prevent weld burn-through
Top edge may be melted through-decreases burn-through difficulty
Arc seam weld along standing rib

Figure 1

As far back as 1960, The Lincoln Electric Company had developed procedures for arc spot welding on 14 to 22 gage steel, single and double thicknesses, and more recently the AISI has conducted research on sheet steel welds, made under the supervision of Raymond Stitt, a member of the AWS Structural Welding Committee. The AISI welds were tested at Cornell University, with the results published in 1971. By using the Cornell test data, it was possible to judge the validity of the Subcommittee's proposed formulas for allowables and to determine critical factors in proposed procedures.

The Arc Spot Weld

Much of the welding with sheet metal will be done with arc spot welds. Here, unlike with groove butts and fillets, there have been no clear-cut methods for analysis of joint strength. An apparently perfect puddle can be established on the top sheet and yet have little or no appreciable penetration into the bottom sheet. See Figure 2.

Figure 2

If the weldor held the electrode over the puddle a bit longer, would he achieve a better joint? The answer is probably no; he would just have made the puddle weld larger. See Figure 3.

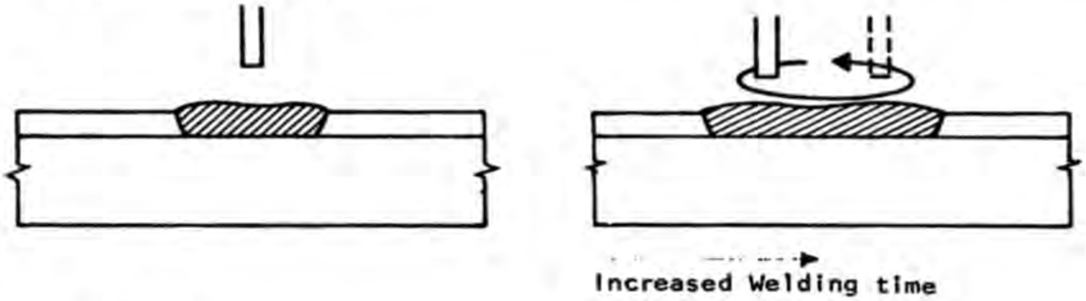


Figure 3

To get penetration into the bottom sheet he would have to increase his current to a point beyond what might be called the "go, no go" current for arc spot welding. Determining the "go, no go" point with different thicknesses of sheet and different electrodes is essential to the development of procedures for arc spot welding. The thermal conductivity through two separate thicknesses of sheet or plate held tightly together is about half of that of a corresponding solid section.

For this reason, if the welding current is inadequate to cause fusion into the bottom sheet most of the heat will flow out transversely and additional welding time will simply spread out the area of melting of the top sheet.

Once the current is high enough to cause melting of the lower member, the thermal conductivity increases and much more heat will flow downward through this interface making it easier for the lower member to melt along with the upper sheet. See Figure 4.

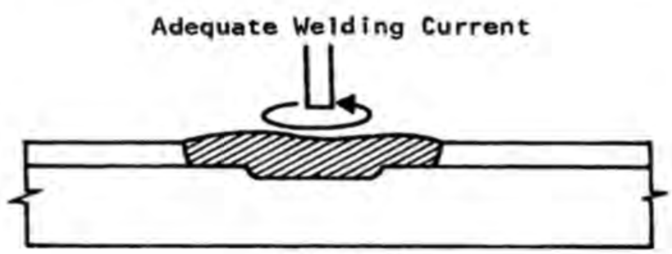


Figure 4

Thus, there is a critical current (with the electrode and steel gage) needed to produce enough heat in the bottom sheet to cause fusion. Once the current is adequate and a breakthrough into the bottom layer occurs, a relationship exists between the diameter of the top and bottom puddles. This relationship can be expressed as a ratio $\frac{d_e}{d}$, as shown in Figure 5 where (d) is the diameter of the top puddle.

	Electrode Melting Rate in/min	Ratio $\frac{d_e}{d}$
12 Gage Galvanized Sheet Steel t = .110"		
5/32" E6011	12.25	0
	13.50	0
	13.75	0
	14.50	0
	16.25	.72
	18.00	.51
3/16" E6011	9.5	0
	10.5	0
	11.0	0
	11.25	0
	11.63	0
	12.0	Slight
	12.25	Slight
	14.5	.40
	16.75	.42
	17.75	.47
	19.50	.42
14 Gage Galvanized Sheet Steel t = .087"		
1/8" E6011	12.25	0
	13.00	0
	14.75	0
	15.25	0
	17.00	.55
	19.40	.61
5/32" E6011	10.75	0
	12.75	0
	14.00	.50
	14.25	.60
	15.00	.62
	15.50	.60
18 Gage Galvanized Sheet Steel t = .045"		
5/32" E6011	8.25	0
	10.25	0
	12.25	0
	12.75	.88
	13.25	.86
	15.00	.88

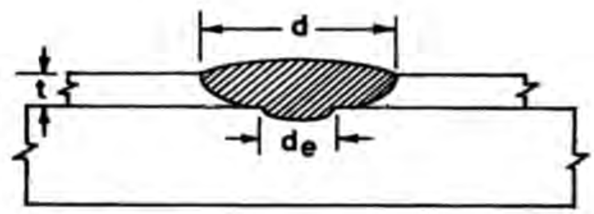


Figure 5

Thus in Figure 5, electrode melting rates are related to $\frac{(d_e)}{d}$ ratios. Note that with 3/16" E6011 electrode on 12 gage sheet, the "go, no go" melting rate (M) is about 14.5 inches per minute. At this melting rate, the current is adequate to cause enough melting in the bottom layer to give a nugget about 40% as wide as the one on the top layer. Note, also, as the sheets become thinner, the ratios rise. But in every case there is a critical melt-off rate (related to current) at which the creation of an arc spot weld is a "go, no go" situation.

Strength of Arc Spot Welds

An arc spot weld, properly executed, has t ree diameters, as illustrated in Figure 6, and test data has shown that a relationship exists between these diameters. As noted in the figure, (d_a), or the average diameter, is related both to the top diameter and the thickness of sheet.

The formulas used for (d_a) are:

$$d_a = d - 2t$$ (double sheet)

And

$$d_a = d - t$$ (single sheet)

These, however, do not give an expression for (d_e). Professor William McGuire, of Cornell University, has determined that the following formula gives a value for (d_e) that best fits test data:

$$d_e = 0.7d - 1.5t$$ t = thickness of single sheet or combined thickness of double sheet

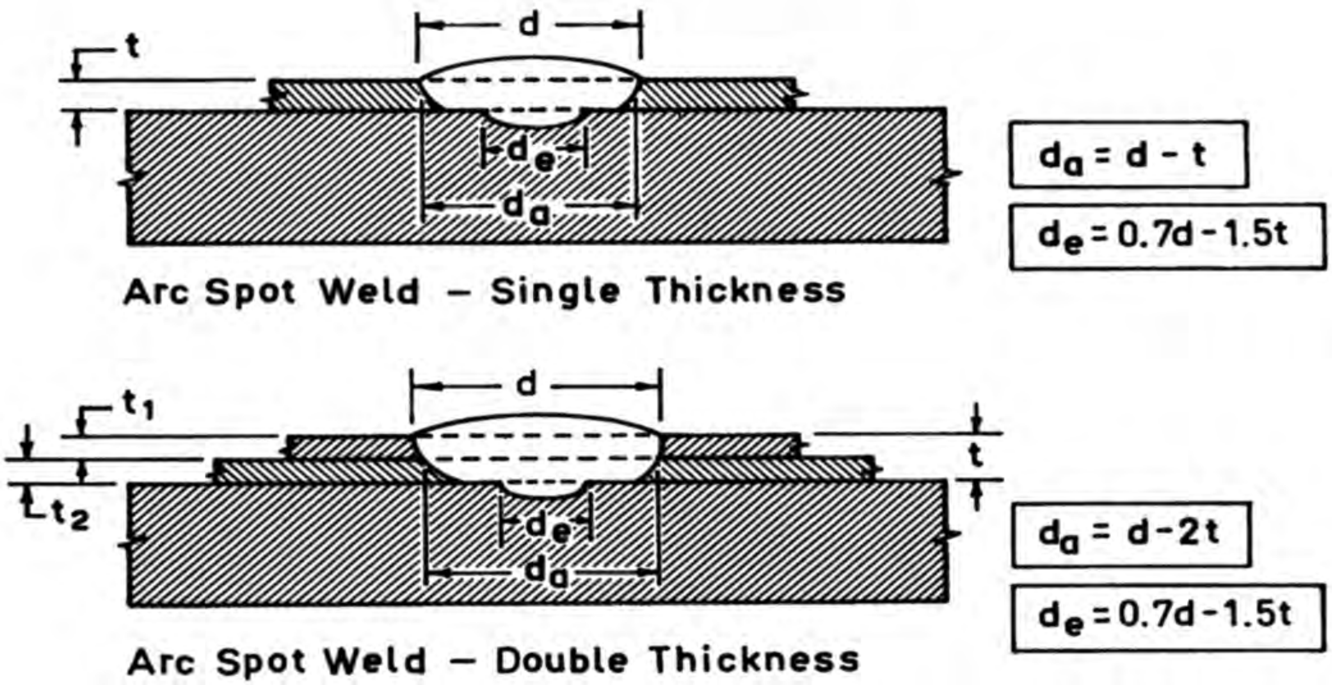
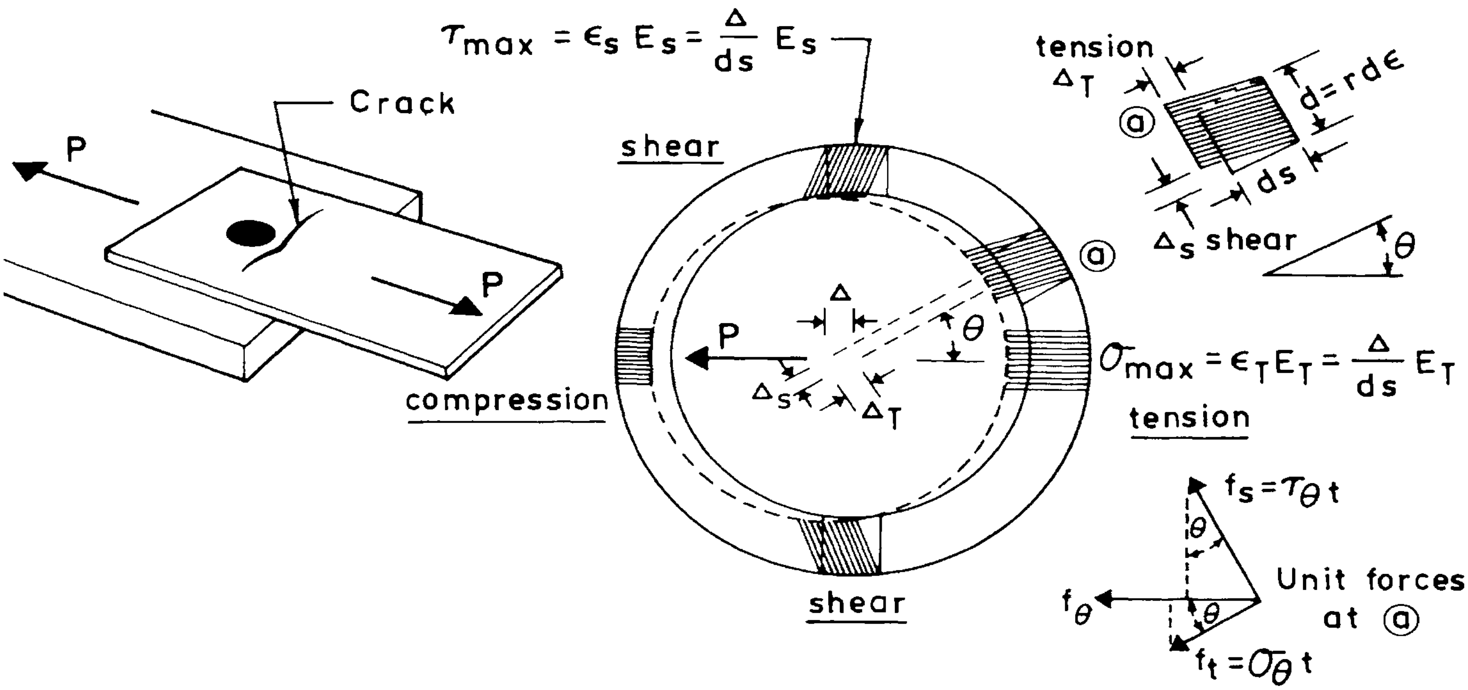


Figure 6

The sheet steel around the circumference of the arc spot weld is subjected to various stresses as it sets up a resisting force. The stress in the sheet is a tensile stress at the leading edge of the weld, becoming a shear stress along the sides, and eventually becoming a compressive stress at the trailing edge of the weld. With progressively increasing loads, the tensile stress at the leading edge will cause a transverse tear to occur in the sheet next to the weld, extending across the sheet as the load increases.

In the following analysis, Figure 7, the arc spot weld will be considered as a rigid pin, forced to move horizontally along the sheet, finally causing the sheet to tear. The resisting force of the sheet around the line of fusion of the weld will be determined.



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$$\Delta_s = \Delta \sin\theta \qquad \Delta_T = \Delta \cos\theta$$

$$\epsilon_s = \frac{\Delta_s}{ds} = \frac{\Delta \sin\theta}{ds} = \frac{\tau_\theta}{E_s} \qquad \epsilon_T = \frac{\Delta_T}{ds} = \frac{\Delta\cos\theta}{ds} = \frac{\sigma_\theta}{E_T}$$

$$\tau_\theta = \frac{E_s\Delta}{ds}\sin\theta = \tau_{max}\sin\theta \qquad \sigma_\theta = \frac{E_T\Delta}{ds}\cos\theta = \sigma_{max}\cos\theta$$

$$f_s = \tau_\theta t \sin\theta = \tau_{max} t \sin^2\theta = \frac{t\Delta}{ds} E_s \sin^2\theta = \frac{t\Delta}{ds} .40 E_T \sin^2\theta = .40\, \sigma_{max} t \sin^2\theta$$

$$f_t = \sigma_\theta t \cos\theta = \sigma_{max} t \cos^2\theta = \frac{t\Delta}{ds} E_T \cos^2\theta = \sigma_{max} t \cos^2\theta$$

$$f_\theta = f_s + f_t = .40\, \sigma_{max} t \sin^2\theta + \sigma_{max} t \cos^2\theta = t\, \sigma_{max}(.40 \sin^2\theta + \cos^2\theta)$$

$$P = 4\int_{\theta=0}^{\theta=\pi/2} f_\theta\, ds = 4\int_{\theta=0}^{\theta=\pi/2} f_\theta\, r\, d\theta = 4 t r \sigma_{max}\int_{\theta=0}^{\theta=\pi/2}(.40 \sin^2\theta + \cos^2\theta)\, d\theta$$

$$P = 4 t r \sigma_{max}\left[.40\left(\frac{\theta}{2} - \frac{\sin\theta\cos\theta}{2}\right) + \frac{\theta}{2} + \frac{\sin\theta\cos\theta}{2}\right]_{\theta=0}^{\theta=\pi/2} = 4 t r \sigma_{max}(.40+1)\frac{\pi}{4}$$

$$P = 1.4\, t\, r\, \pi\, \sigma_{max} \quad \text{or} \quad P = 0.7\, t\, d_a \pi\, \sigma_{max}$$

$$\text{or} \quad \boxed{P = 2.2\, t\, d_a\, \sigma_{allowable}}$$

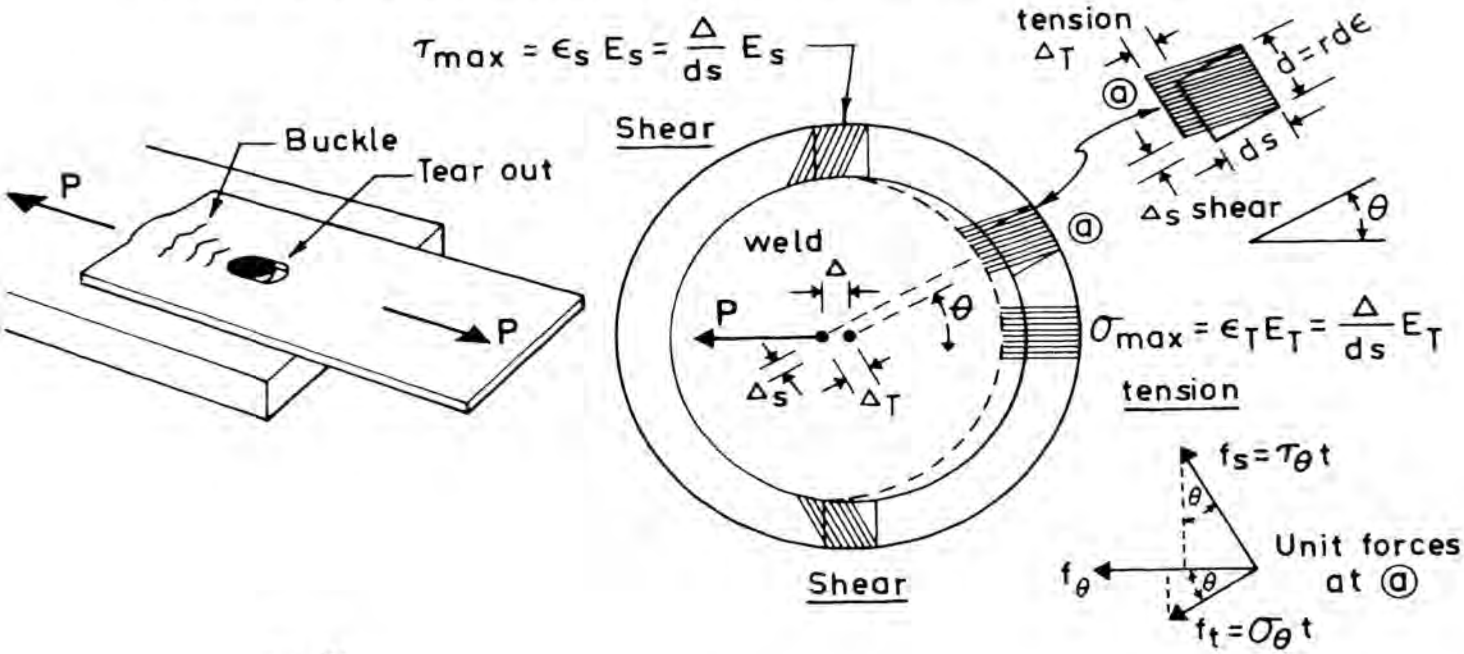
Figure 7

In the above, notice the maximum shear stress (r) will be E/E or 0.40 of the maximum tensile stress (o). This means for steel, the initial failure will be in tension and will occur as shown in the upper left figure. Once this initial crack occurs, it will probably continue across the sheet.

If the sheet is sufficiently thin, there may be a tendency for it to buckle near the trailing edge of the weld. This will decrease the resisting force of the joint, and failure will occur initially by tension at the leading edge, and then tearing out in shear along the sides of the weld.

In this analysis, Figure 8, the resistance of the weld in the compression has been removed. The resisting force of the sheet around the line of fusion of the weld due to shear and tension will be determined.

In this analysis, we will assume the sheet is very thin and will buckle on the compression side of the arc spot weld. This will remove the resistance of the weld in this compression region. The resisting force of the sheet around the line of fusion of the weld due to shear and tension will be determined.



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$$\Delta_s = \Delta \sin\theta \qquad \Delta_T = \Delta\cos\theta$$

$$\epsilon_s = \frac{\Delta_s}{ds} = \frac{\Delta\sin\theta}{ds} = \frac{\tau_\theta}{E_s} \qquad \epsilon_T = \frac{\Delta_T}{ds} = \frac{\Delta\cos\theta}{ds} = \frac{\sigma_\theta}{E_T}$$

$$\tau_\theta = \frac{E_s\Delta}{ds}\sin\theta = \tau_{max}\sin\theta \qquad \sigma_\theta = \frac{E_T\Delta}{ds}\cos\theta = \sigma_{max}\cos\theta$$

$$f_s = \tau_\theta t \sin\theta = \tau_{max} t \sin^2\theta = \frac{t\Delta}{ds} E_s \sin^2\theta = \frac{t\Delta}{ds} .40 E_T \sin^2\theta = .40\,\sigma_{max}\, t \sin^2\theta$$

$$f_T = \sigma_\theta t \cos\theta = \sigma_{max} t \cos^2\theta = \frac{t\Delta}{ds} E_T \cos^2\theta = \sigma_{max}\, t \cos^2\theta$$

Here the total resisting force is made up of tension and shear, no compression

$$P = 4\int_{\theta=0}^{\theta=\pi/2} f_s\, r\, d\theta = 2\int_{\theta=0}^{\theta=\pi/2} f_t\, r\, d\theta = 4 t r \sigma_{max}\int_{\theta=0}^{\theta=\pi/2} .40 \sin^2\theta\, d\theta + 2 t r \sigma_{max}\int_{\theta=0}^{\theta=\pi/2} \cos^2\theta\, d\theta$$

$$P = 1.60\, t r \sigma_{max}\left[\frac{\theta}{2} - \frac{\sin\theta\cos\theta}{2}\right]_{\theta=0}^{\theta=\pi/2} + 2 t r \sigma_{max}\left[\frac{\theta}{2} + \frac{\sin\theta\cos\theta}{2}\right]_{\theta=0}^{\theta=\pi/2} = t r \sigma_{max}\left(1.60\frac{\pi}{4} + 2\frac{\pi}{4}\right)$$

$$P = 0.9\, t\, r\, \pi\, \sigma_{max} = 0.45\, t\, d\, \pi\, \sigma_{max}$$

$$\boxed{P = 1.4\, t\, d_a\, \sigma_{max}}$$

Figure 8

It is necessary, of course, to know when to apply the latter formula -- the one that applies to buckling. It can be shown (For example, see Design of Weldments, Section 2.12 published by The James F. Lincoln Arc Welding Foundation) that when (d/t) is greater or equal to $\frac{240}{\sqrt{\sigma_y}}$, buckling of a sheet is likely to occur, in which case the formula $P = 1.4\ t\ d$ should be used. If the ratio (d/t) is less than $\frac{240}{\sqrt{\sigma_y}}$, the formula $P = 2.2\ t\ d\ \sigma$ is applicable.

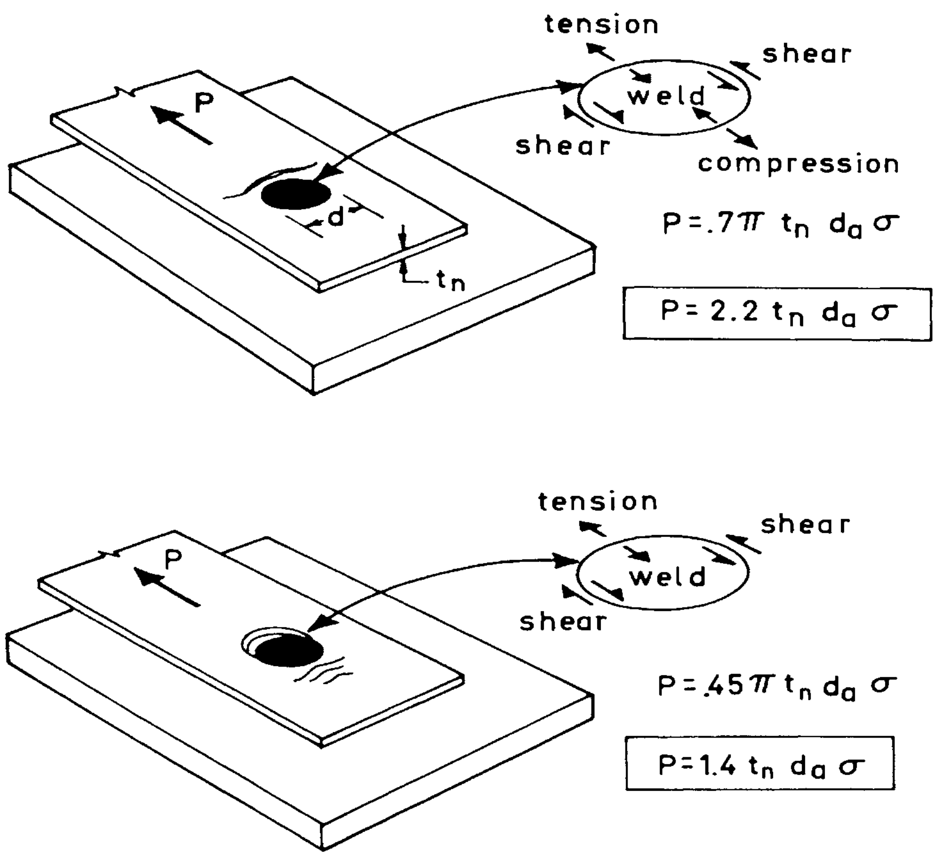


Figure 9

Theoretical values obtained by the above formulas were compared with actual test data f m Cornell University, and a good correlation was found to exist.

ARC SPOT WELDS - SINGLE SHEET

Arc Spot Welds

Single Sheet	Actual t	Net t_n	Diameter Weld d	$\frac{d}{t}$ $\frac{240}{\sqrt{\sigma_y}}$	Actual Strength kips	$P=2(2.2)t_n d_a \sigma_{ult}$ Calculated	$P=2(1.4)t_n d_a \sigma_{ult}$ Calculated
18 ga sheet	.051	.050	.78	15.3 < 35.0	13.48	10.34	
	.052	.050	.83	16.0 < 35.0	12.40	11.05	
	.051	.050	.80	15.7 < 35.0	13.10	10.63	
	.052	.050	.85	16.3 < 35.0	14.40	11.33	
28 ga sheet	.018	.017	.65	36.1 > 24.3	2.76		2.94
	.018	.017	.63	35.0 > 24.3	1.94		2.85
	.018	.017	.58	32.2 > 24.3	2.60		2.62
	.018	.017	.58	32.2 > 24.3	2.54		2.62
	.018	.017	.53	29.4 > 24.3	2.72		2.38

Figure 10

ARC SPOT WELDS - DOUBLE SHEET

Double Sheet	Actual Double t	Net Double t_n	Dia. Weld d	$\frac{d}{t}$ $\frac{240}{\sqrt{\sigma_y}}$	Actual Strength kips	$P=2(2.2)t_n d_a \sigma_{ult}$ Calculated	$P=2(1.4)t_n d_a \sigma_{ult}$ Calculated
18 ga sheet	.099	.096	1.38	13.9 < 35.0	28.60	32.32	
	.099	.096	1.35	13.6 < 35.0	37.30	31.50	
	.099	.096	1.35	13.6 < 35.0	32.40	31.50	
	.101	.098	1.40	13.9 < 35.0	26.30	32.86	

Figure 11

In Figures 10 and 11 calculated values for the strengths of arc spot welds are correlated with the actual strengths tested at Cornell University. The first item, Figure 10, is a single sheet, 18 gage galvanized, welded to a 7 gage supporting member. The actual thickness (t) is .051", which gives a net thickness (t_n) of .050 after subtracting for the galvanizing. The diameter of the weld (d) was .78". Diameter divided by thickness is, thus, $d/t = 15.3$, and this is less than the critical value of $\frac{240}{\sqrt{\sigma_Y}} = 35.0$, which suggests that failure would be on the $P = 2.2\ t\ d\ \sigma$ basis.

The sheet has an ultimate tensile strength of 64.4 SKI, there are two welds, (one on each side of the bar) and $d_a = d - t = .73$. Using the formula:

$$P = 2\ (2.2)\ t_n\ d_a\ \sigma_{ult}$$

$$= 2\ (2.2)\ (.05)\ (.73)\ (64.4)$$

$$= 10.34 \text{ Kips}$$

The calculated strength of 10.34 kips is less than the actual strength of 13.48 kips as determined by testing. The difference may seem considerable, but the calculated value is, at least, a "ball park" figure -- and it is on the conservative side. Similarly, with other weld diameters (d), as the figure shows, the calculated strengths are less than the tested strengths with 18 gage sheet.

In the lower half of Figure 10 data on 28 gage sheet welded to 7 gage material are presented. With such thin sheet, one would expect failure to occur with a tearing out (shear) around the weld rather than failure of the sheet. The value (d/t) is greater than $\frac{240}{\sqrt{\sigma_Y}}$, so the formula $P = 1.4\ t\ d\ \sigma$ is applicable in the calculation. As can be seen, the calculated values for strength, using this basic formula, are close to the actual strength values.

In going from 18 gage sheet to 28 gage sheet, it is obvious that a point has been crossed where the type of failure changes. However, the data are not complete enough to show exactly where this is -- namely, the cross-over point in sheet thickness where (d/t) changes from being less than $\frac{240}{\sqrt{\sigma_Y}}$ to being greater.

Figure 11 gives similar data on tests with double sheet. Here (d) is taken as equal to (d - 2t). Again, the calculated values roughly approximate test results.

In Figure 12 the calculated strengths of arc spot welds are plotted against their actual strengths. The resulting 45° line represents a reasonable approximation of the relationship.

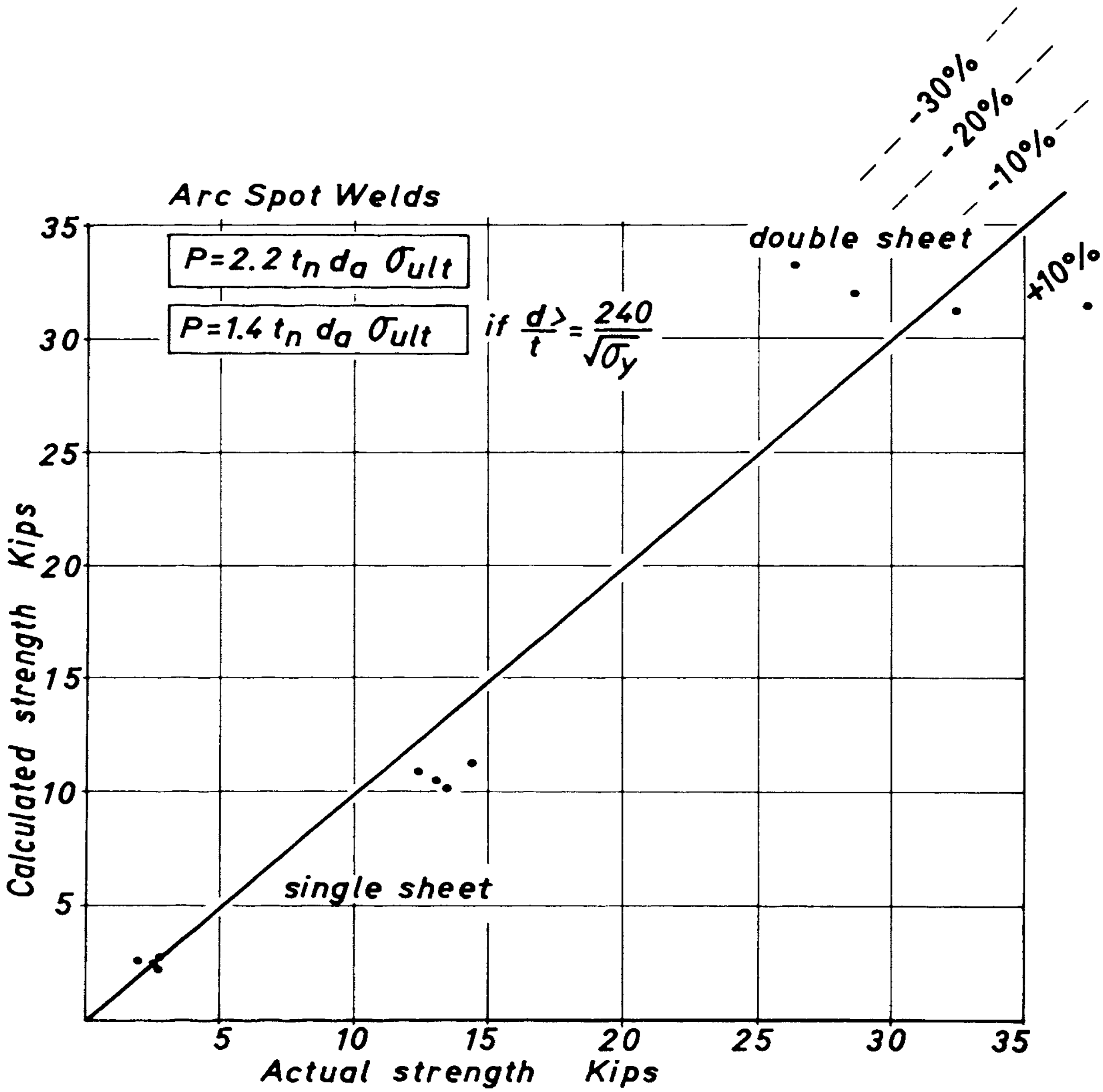

Arc Spot Welds
P=2.2 t_n d_a σ_{ult}
P=1.4 t_n d_a σ_{ult}
if $\frac{d}{t} \geq \frac{240}{\sqrt{\sigma_y}}$
double sheet
single sheet
-30%
-20%
-10%
+10%
Calculated strength Kips
Actual strength Kips
5
10
15
20
25
30
35

Figure 12

Arc Seam Welds

In some applications, there is not room for a full width arc spot weld (such as in flutes of decking). Lowering the current in an attempt to narrow the width of the spot does not work, since that drops the current below the critical point for penetration into the underlying member. However, with movement of the arc longitudinally, an arc seam weld is produced, which does have penetration. If the current necessary for an arc spot weld is maintained while running an arc seam weld, one can be assured that a good arc seam weld will result. Arc seam welds were not tested in this program but are used successfully by fabricators of structural sheet steel products.

Referring to Figure 13 it is assumed that the total resisting force (P) of the weld is the sum of the resisting forces of the two half circle ends, plus the resisting force of two sides of the weld.

This formula applies when (d/t) is less than $\frac{240}{\sqrt{\sigma_y}}$. If (d/t) is equal to or greater than $\frac{240}{\sqrt{\sigma_y}}$, the capacity of the arc seam would be reduced by the resisting force of one of the half circle ends and --

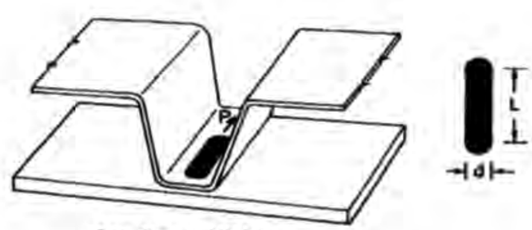
$$P = 0.45\ t\ d_a \pi \sigma \quad + \quad t\ L\ \tau$$

$$= 0.45\ t\ d_a \pi\ ^{3}\!/_{2}\, \tau \quad + \quad t\ L\ \tau$$

$$= 2\ t\ \tau\ (\tfrac{L}{2} + 1.06\ d_a)$$

or use

$$P = 2\ t\ \tau\ (\tfrac{L}{2} + d_a)$$



Arc Seam Weld

Single sheet: $P = 2t\left[\frac{L}{2} + 1.6(d-t)\right]\tau$

Double sheet: $P = 2t\left[\frac{L}{2} + 1.6(d-2t)\right]\tau$

If $\frac{d}{t} \geq \frac{240}{\sqrt{\sigma_y}}$

Single sheet: $P = 2t\left[\frac{L}{2} + (d-t\right]\tau$

Double sheet: $P = 2t\left[\frac{L}{2} + (d-2t)\right]\tau$

Figure 13

Fillet Welds

Fillet welds may be used when sheet is lap-welded to plate or to another sheet. These are illustrated in Figure 14.

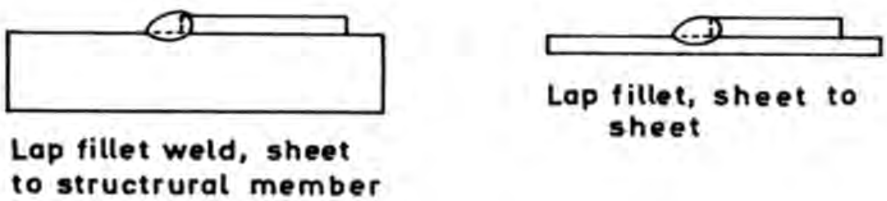


Figure 14

These may be used in T joints as in Figure 15.

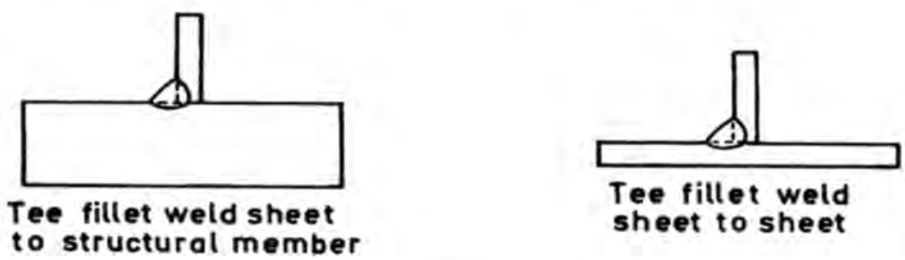


Figure 15

In respect to fillets, there is an important difference between plate welding and sheet welding. With plate, the strength of the attachment depends on the throat of the weld, which is .707 times the leg size (w). Here, the weld throat is critical; if failure occurs, it will likely occur in the weld. On the other hand, with a properly executed fillet in sheet steel, the penetration is greater and if failure occurs it will probably be in the sheet material itself rather than in the weld. Therefore, the thickness of the sheet is critical.

The strength of a fillet weld loaded transverse depends upon (1) the thickness of the sheet, (2) the length of the welded joint and (3) the tensile strength of the sheet. The allowable for the joint is thus:

$$\sigma_{Allowable} = \frac{\sigma_{Ultimate}}{2.5} = .40\ \sigma_{Ultimate}$$

Should the load be parallel rather than transverse, the question arises as to what allowable should be used for shear, using the AISI factor of safety. One accepted method of rating shear in steel is using 3/4 of the tensile strength. Thus, if .40 σ ultimate is used for the tensile allowable at the joint --

$$\tau_{Allowable} = 3/4\ (.40)\ \sigma_{Ultimate} = .30\ \sigma_{Ultimate}$$

Longitudinal Fillet Welds -- Flat Sheet

The resisting force (P) on a longitudinal fillet weld in flat sheet can be calculated by the formula:

$$P = t\ L\ \tau$$

$$P = 1.6\ t^{1.2}\ L^{1/3}\ \sigma$$

Figure 16

It is a known fact that in plate welding the unit strength of a fillet is greater to a certain extent the shorter the weld. Since most fillet welds in plate have appreciable length, credit is not taken for the greater unit strength that goes with shorter lengths. In sheet steel welding, unit strength is also greater, but here consideration should be given to the higher unit values since the welds are usually short welds. One of the reasons that short welds have greater unit strength is that the short duration of the arc lessens the heating of adjacent metal, and thus lessens the softening of it.

If the weld is not over 2-1/2" long, a revised formula that takes into account the "extra strength" resulting from its brevity will give greater accuracy as substantiated by testing programs:

$$P = 1.6\ t^{1.2}\ L^{1/3}\ \sigma$$

The graphs in Figures 17 and 18 show calculated strengths by these two formulas plotted against test data. Note that the scatter about the diagonal lines is less with the formula for short welds.

Transverse Fillet Welds -- Flat Sheet

As can be seen by Figure 19, the formula

$$P = t\ L\ \sigma$$

works out very well in predicting the strength of transverse fillets in flat sheet.

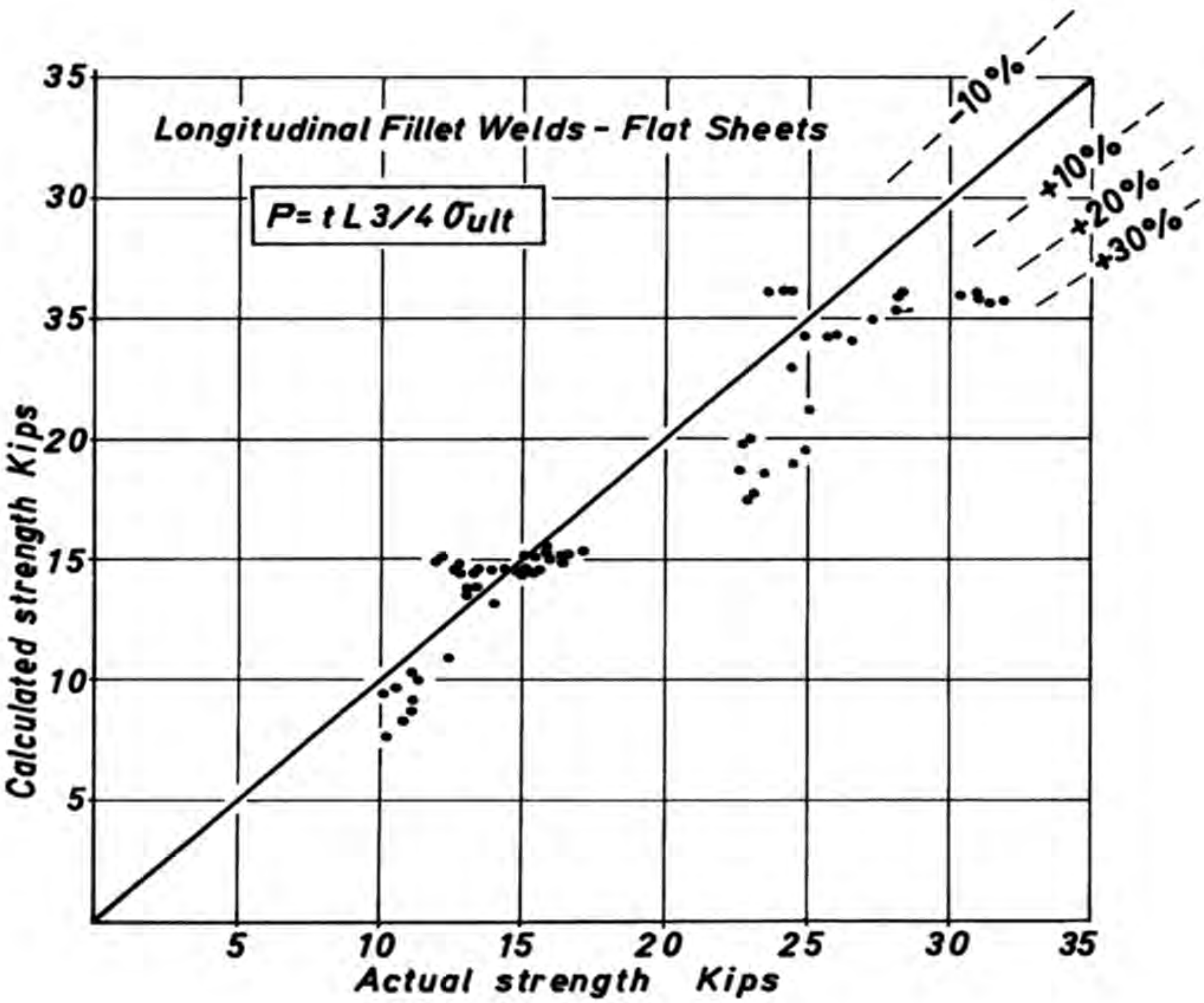
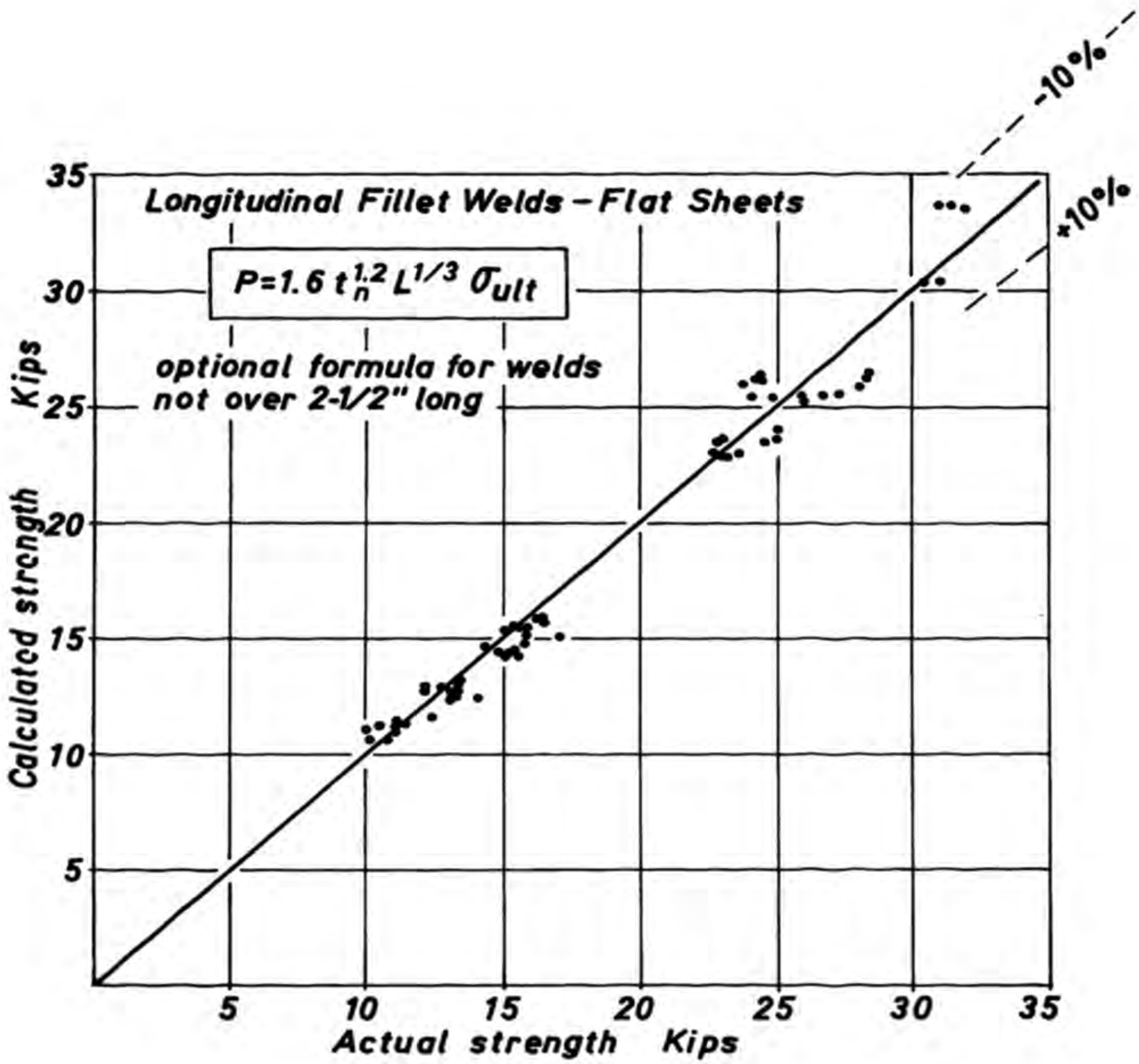

Longitudinal Fillet Welds - Flat Sheets
P= t L 3/4 σult
-10%
+10%
+20%
+30%
Calculated strength Kips
Actual strength Kips
35
30
25
20
15
10
5
5
10
15
20
25
30
35

Figure 17



Longitudinal Fillet Welds - Flat Sheets
$P=1.6\,t_n^{1.2}\,L^{1/3}\,\sigma_{ult}$
optional formula for welds
not over 2-1/2" long
-10%
+10%
Calculated strength Kips
Actual strength Kips
5
10
15
20
25
30
35

Figure 18

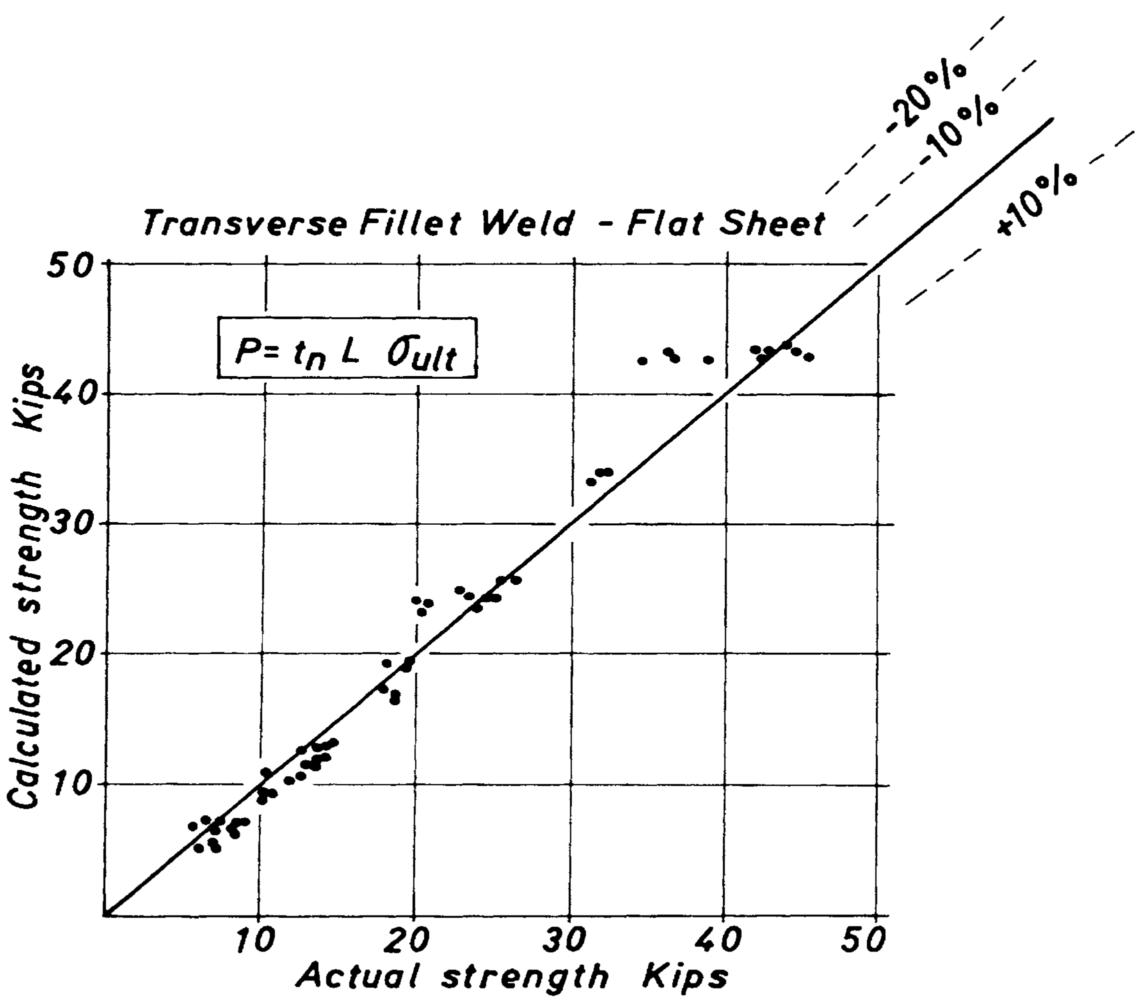

Transverse Fillet Weld - Flat Sheet
-20%
-10%
+10%
P= t_n L σ_{ult}
Calculated strength Kips
Actual strength Kips
10
20
30
40
50
10
20
30
40
50

Figure 19

Flare Bevel and Flare Vee Groove Welds

Welds in sheet steel welding may be "flare bevel" or "flare V", as illustrated in Figure 20. The forming of sheet steel to develop curves at the weld joints is responsible for producing the "flare".

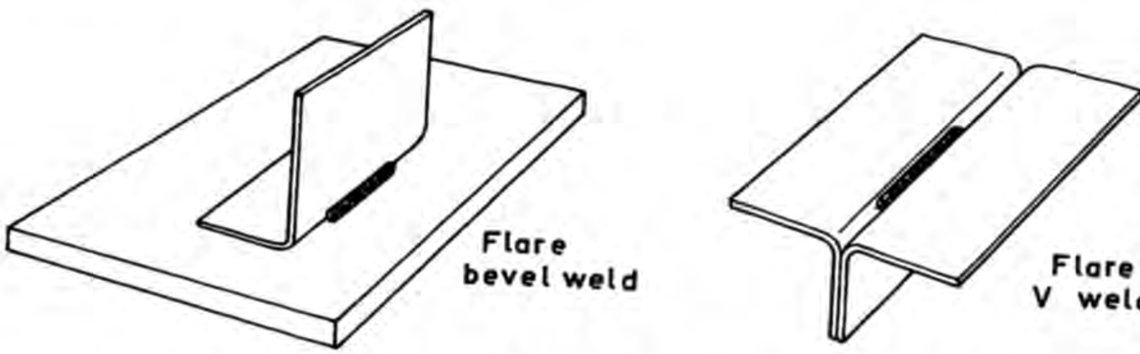


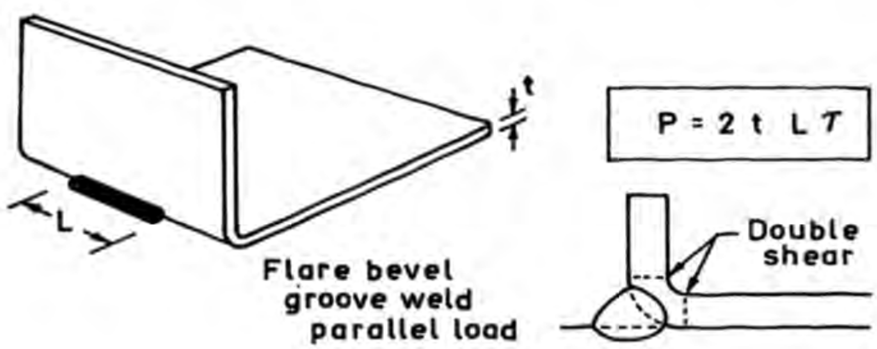
Figure 20

Longitudinal Flare Bevel Welds -- Channel Sections

A flare bevel weld between a channel and a flat surface is treated the same as a fillet. If the flange of the formed sheet is rather narrow -- merely ends without imposing a path for stress through its length -- the flare bevel is considered to be in single shear. The resisting force (P) is then:

$$P = t\,L\,\tau$$

If the flange is rather wide, the joint is said to be in double shear and the resisting force becomes:



$$P = 2\,t\,L\,\tau$$

Figure 21

Transverse Flare Bevel Welds -- Channel

With a flare bevel weld between the flange of a formed section and flat surface subject to transverse stress, there may exist some eccentricity. To take this into account, it has been determined by experiment that the calculated resisting force should be reduced by about 20%. For this reason, the formula becomes:

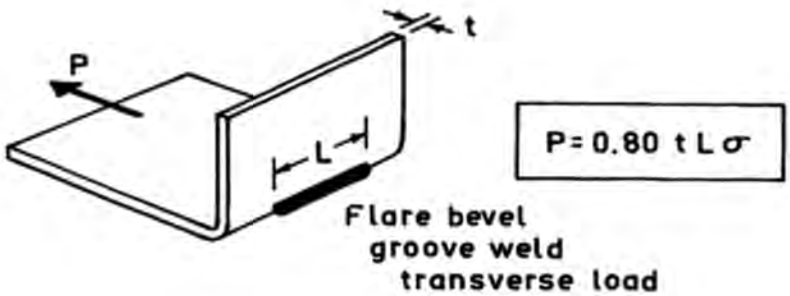


Figure 22

Figures 23 and 24 show calculated versus actual strength values for such flare bevel welds. Here, again the scatter of points about the 45° line tends to support the validity of the formulas, with the major deviations being on the side of conservative design.

With this and the preceding formulas, allowable stresses would be used for design calculations. Ultimate strength values for the joint were used in calculating the ultimate str ngth of the joints in order to compare them with actual test data.

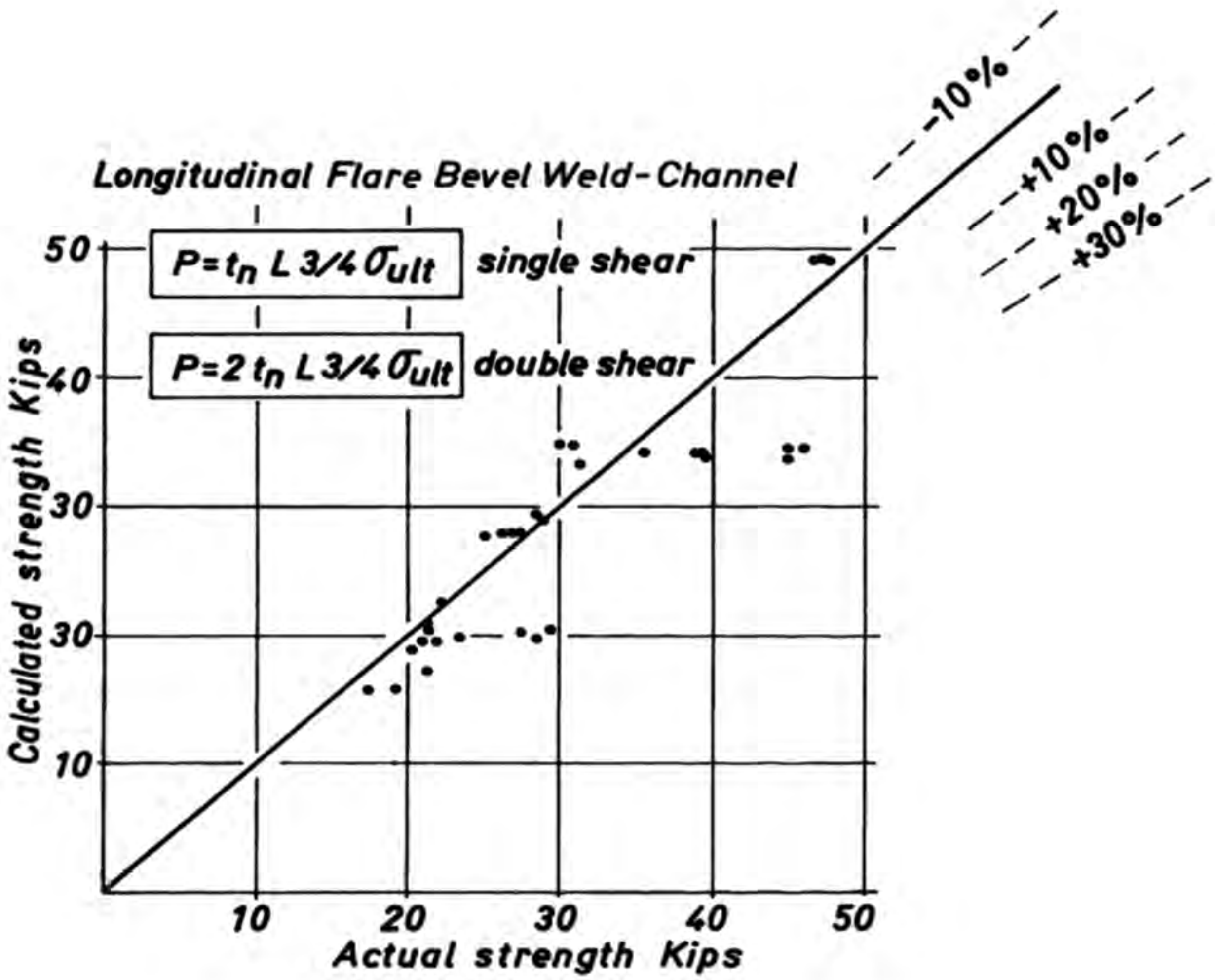

Longitudinal Flare Bevel Weld-Channel
P=t_n L 3/4 σ_ult single shear
P=2 t_n L 3/4 σ_ult double shear
-10%
+10%
+20%
+30%
Calculated strength Kips
50
40
30
30
10
10
20
30
40
50
Actual strength Kips

Figure 23

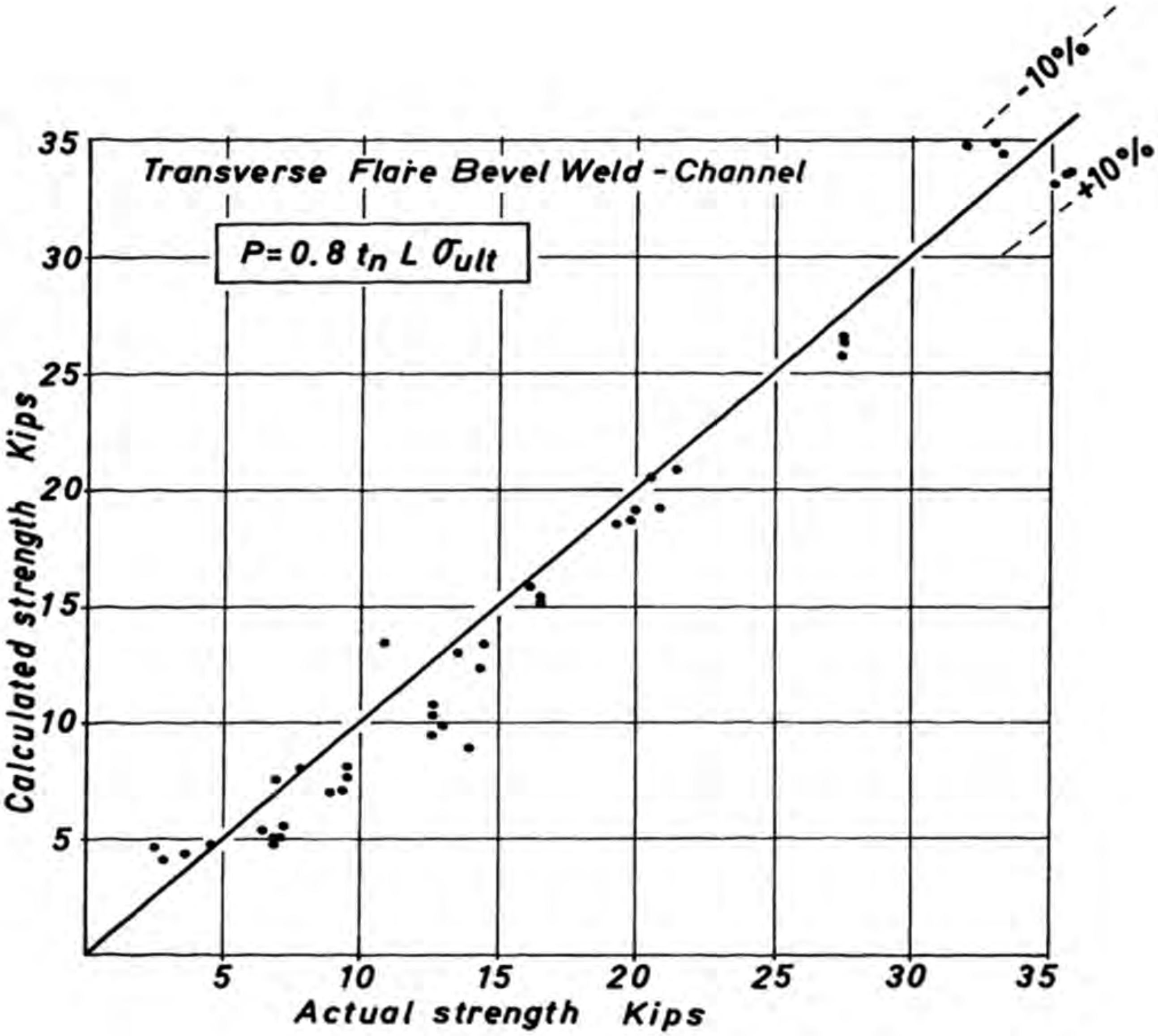

Transverse Flare Bevel Weld - Channel
P= 0.8 t_n L σ_ult
-10%
+10%
35
30
25
20
15
10
5
Calculated strength Kips
5
10
15
20
25
30
35
Actual strength Kips

Figure 24

SUMMARY

This report merely sketches the basis for the proposed standards for sheet steel structural welding. The standards, as written, are more detailed. They include welding technique, procedure qualification, operator qualification, workmanship, inspection, commentary and terms and definitions. The purpose of this report has been to show the approach taken by Subcommittee 11 and the logic of the approach.

With sheet steel welding, the variables cannot be as closely defined as with plate welding, and empirical consideration overshadows theoretical analysis. Nevertheless, the Subcommittee feels that the proposed standards represents a pragmatic path for assuring the integrity of structures fabricated from sheet steel.