Autodesk Inventor Engineer s Handbook

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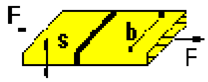
Joints / Fixed Joints

Solder Joint Calculator

butt joint calculation



Allowable stress

$$\sigma_A = \frac{S_U}{k_T}$$

Joint tensile stress

$$\sigma = \frac{F}{b \cdot s}$$

Minimum part thickness

$$s_{min} = \frac{F}{b \cdot \sigma_A}$$

Strength check

$\sigma \leq \sigma_A$

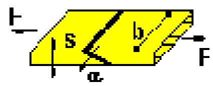
Meaning of used variables for metric units:

S_U Joint strength in tension [MPa]
k_T Tension safety factor
F Transferred force [N]
b Width of connected parts [mm]
s Thickness of connected parts [mm.

Meaning of used variables for English units:

S_U Joint strength in tension [psi]
k_T Tension safety factor
F Transferred force [lb]
b Width of connected parts [in]
s Thickness of connected parts [in]

Bevel solder joint calculation



Allowable joint tensile stress

$$\sigma_A = \frac{S_U}{k_T}$$

Allowable joint shear stress

$$\tau_A = \frac{S_{US}}{k_S}$$

Joint tensile stress

$$\sigma = \frac{F \cdot \sin^2\left(\frac{\alpha \cdot \pi}{180}\right)}{b \cdot s}$$

Joint shear stress

$$\tau = \frac{F \cdot \sin\left(\frac{\alpha \cdot \pi}{180}\right) \cdot \cos\left(\frac{\alpha \cdot \pi}{180}\right)}{b \cdot s}$$

Strength check

$\sigma \leq \sigma_A$ and $\tau \leq \tau_A$

Minimum thickness of connected parts

$s_{min} = \max \{s_1, s_2\}$

where:

$$s_1 = \frac{F \cdot \sin^2\left(\frac{\alpha \cdot \pi}{180}\right)}{b \cdot \sigma_A} \qquad s_2 = \frac{F \cdot \sin\left(\frac{\alpha \cdot \pi}{180}\right) \cdot \cos\left(\frac{\alpha \cdot \pi}{180}\right)}{b \cdot \tau_A}$$

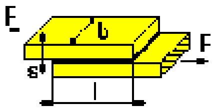
Meaning of used variables for metric units:

S_U Joint strength in tension [MPa]
k_T Tension safety factor
S_{US} Joint strength in shear [MPa]
k_S Shear safety factor
F Transferred force [N]
b Width of connected parts [mm]
s Thickness of connected parts [mm]

Meaning of used variables for English units:

S_U Joint strength in tension [psi]
k_T Tension safety factor
S_{US} Joint strength in shear [psi]
k_S Shear safety factor
F Transferred force [lb]
b Width of connected parts [in]
s Thickness of connected parts [in]

Lap solder joint calculation



Allowable stress

$$\tau_A = \frac{S_{us}}{k_s}$$

Joint shear stress

$$\tau = \frac{F}{b \cdot L}$$

Minimum overlap length

$$L_{min} = \frac{F}{b \cdot \tau_A}$$

Strength check

$\tau \le \tau_A$

Design of optimum overlap length

Anticipates that any breakage occurs in the joint itself, and not in the basic material.

$L_{opt} = \max \{L_{min}, L_1\}$

where:

$$L_1 = \frac{S_{ub} \cdot s}{S_{us}}$$

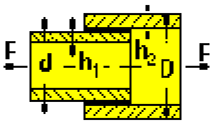
Meaning of used variables for metric units:

S_{US} Joint strength in shear [MPa]
k_S Shear safety factor
F Transferred force [N]
b Width of connected parts [mm]
s Thickness of connected parts [mm]
S_{Ub} Tensile strength of basic material [MPa]
L Length of overlap [mm].

Meaning of used variables for English units:

S_{US} Joint strength in shear [psi]
k_S Shear safety factor
F Transferred force [lb]
b Width of connected parts [in]
s Thickness of connected parts [in]
S_{Ub} Tensile strength of basic material [psi]
L Length of overlap [in]

Step tube joint calculation



Allowable stress

$$\tau_A = \frac{S_{us}}{k_s}$$

Joint shear stress

$$\tau = \frac{F}{\pi \cdot d \cdot L}$$

Minimum step depth

$$L_{min} = \frac{F}{\pi \cdot d \cdot \tau_A}$$

Strength check

$\sigma \leq \sigma_A$

Design of optimum step depth

Anticipates that a joint is designed so that any breakage occurs in the joint itself, and not in the basic material.

$L_{opt} = \max \{L_{min}, L_1\}$

where:

$$L_1 = \frac{S_{ub} \cdot f}{S_{us}}$$

and the joint factor f:

for $h_1 < h_2$:

$$f = \left(1 - \frac{h_1}{d}\right) \cdot h_1$$

for $h_1 > h_2$:

$$f = \left(1 + \frac{h_2}{d}\right) \cdot h_2$$

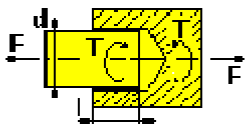
Meaning of used variables for metric units:

S_{US} Joint strength in shear [MPa]
k_S Shear safety factor
S_{Ub} Tensile strength of basic material [MPa]
d Diameter of inner tube or step diameter [mm]
L Step depth [mm]
h_1 Tube thickness of inner tube [mm]
h_2 Tube thickness of outer tube [mm]

Meaning of used variables for English units:

S_{US} Joint strength in shear [psi]
k_S Shear safety factor
S_{Ub} Tensile strength of basic material [psi]
d Diameter of inner tube or step diameter [in]
L Step depth [in]
h_1 Tube thickness of inner tube [in]
h_2 Tube thickness of outer tube [in]

Step solder joint calculation



Metric units

Joint allowable stress

$$\tau_A = \frac{S_{us}}{k_s} \quad [MPa]$$

Shear stress from force

$$\tau_1 = \frac{F}{\pi \cdot d \cdot L} \quad [MPa]$$

Shear stress from moment

$$\tau_2 = \frac{2 \cdot 1000 \cdot T}{\pi \cdot d^2 \cdot L} \quad [MPa]$$

Resulting reduced stress

$$\tau_{red} = \sqrt{\tau_1^2 + \tau_2^2} \quad [MPa]$$

Strength check

$\tau_{red} \leq \tau_A$

Minimum step depth

$$L_{min} = \sqrt{\left(\frac{2 \cdot 1000 \cdot T}{\pi \cdot d^2 \cdot \tau_A}\right)^2 + \left(\frac{F}{\pi \cdot d \cdot \tau_A}\right)^2} \quad [mm]$$

Design of optimum overlap length

Anticipates that a joint is designed so that any breakage occurs in the joint itself, and not in the basic material.

$L_{opt} = \max \{L_{min}, L_1\}$

where:

$$L_1 = \frac{S_{Ub} \cdot d}{S_{Us} \cdot 4} \quad [mm]$$

Meaning of used variables for metric units:

S_{Us} Joint strength in tension [MPa]
k_S Shear safety factor
S_{Ub} Tensile strength of basic material [MPa]
F Transferred force [N]
d Step diameter [mm]
L Step depth [mm]
T Torque [MPa]

English units

Joint allowable stress

$$\tau_A = \frac{S_{Us}}{k_S} \quad [psi]$$

Shear stress from force

$$\tau_1 = \frac{F}{\pi \cdot d \cdot L} \quad [MPa]$$

Shear stress from moment

$$\tau_2 = \frac{2 \cdot 12 \cdot T}{\pi \cdot d^2 \cdot L} \quad [psi]$$

Resulting reduced stress

$$\tau_{red} = \sqrt{\tau_1^2 + \tau_2^2} \quad [psi]$$

Strength check

$\tau_{red} \leq \tau_A$

Minimum step depth

$$L_{min} = \sqrt{\left(\frac{2 \cdot 12 \cdot T}{\pi \cdot d^2 \cdot \tau_A}\right)^2 + \left(\frac{F}{\pi \cdot d \cdot \tau_A}\right)^2} \qquad [in]$$

Design of optimum overlap length

Anticipates that a joint is designed so that any breakage occurs in the joint itself, and not in the basic material.

$L_{opt} = \max \{L_{min}, L_1\}$

where:

$$L_1 = \frac{S_{Ub} \cdot d}{S_{US} \cdot 4} \qquad [in]$$

Meaning of used variables for metric units:

S_{Us} Joint strength in tension [MPa]
k_S Shear safety factor
S_{Ub} Tensile strength of basic material [MPa]
F Transferred force [N]
d Step diameter [mm]
L Step depth [mm]
T Torque [MPa]

Guiding values for strength of solder joints

During static loading, metric units

Jointed Material	*Solder Type*	*Tension* R $_m$ [MPa]	*Shear* R $_{ms}$ [MPa]
	Tin solders	30 to 80	20 to 40
Low strength steels (for example, 37 grade)	Solders from Cu alloys	200 to 350	100 to 220
	Silver solders	220 to 400	120 to 2520

During static loading, English units

Jointed Material	*Solder Type*	*Tension* R $_m$ [psi]	*Shear* R $_{ms}$ [psi]
	Tin solders	4 500 to 11 500	2 900 to 5 800
Low strength steels (for example, 37 grade)	Solders from Cu alloys	29 000 to 50 000	14 500 to 32 000
	Silver solders	32 000 to 58 000	17 500 to 36 000

use on copper, brass, and similar metals with torch heating

Generally used for high temperature properties and compatibility with cobalt-based metals.

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