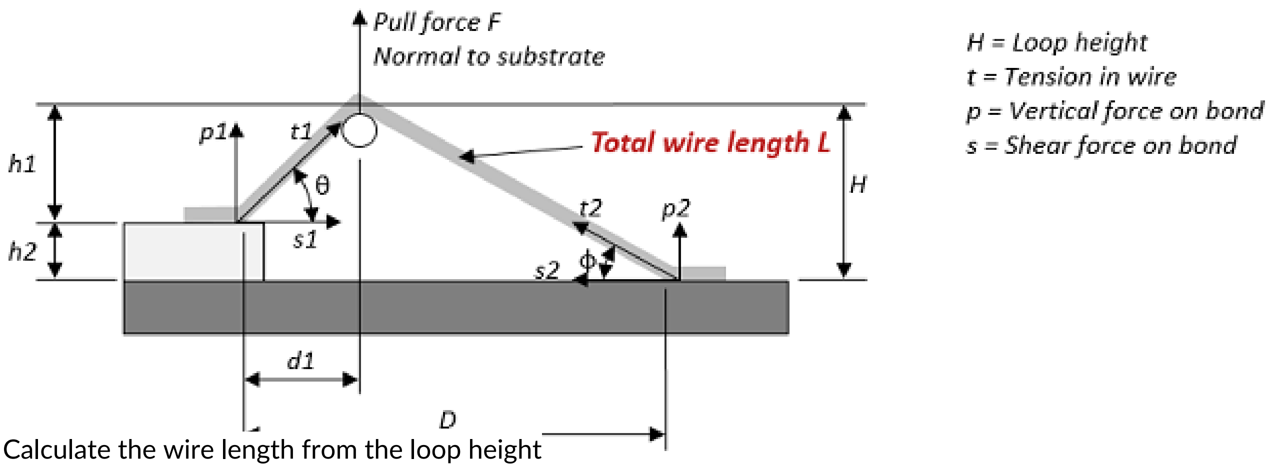
How to test bonds » Wire Pull » Appendices » force calculations

Appendix i. Force calculations

a. Wire length L

If the geometry of the sample and the wire length are known the resultant angles and forces on the bonds during wire pull can be determined. If the wire length L is unknown, it can be calculated from the loop height.



Calculate the wire length from the loop height

The general equation is as follows:

$$L = \sqrt{d_1^2 + (H - h_2)^2} + \sqrt{d_2^2 + H^2}$$

If there is no height difference between the first and second bond and the pulltest is performed mid span, the equation can be simplified to:

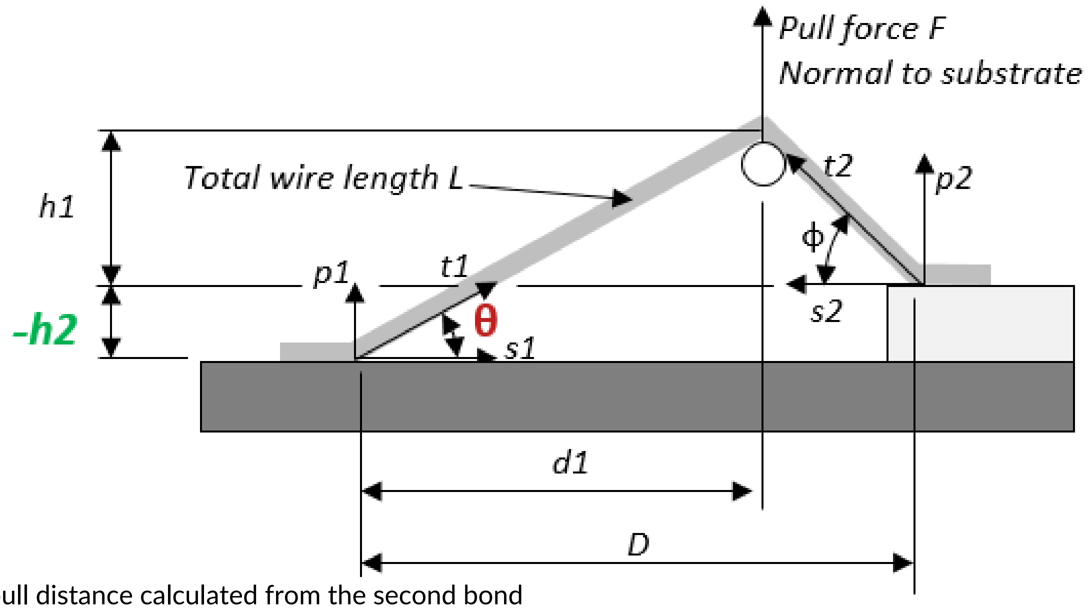
$$L = 2\sqrt{\frac{D^2}{4} + H^2}$$

b. Position d1 from first bond angle θ

If you want to pull with a specific angle θ at the first bond, calculate the test position along the wire according to the following formula.

$$d_1 = \frac{\left(\left(\frac{h_2}{Sin\theta}\right)^2 - L^2 + \left(D + \frac{h_2}{\mathrm{Tan}\ \theta}\right)^2 - 2\frac{h_2}{Sin\theta}\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta\right)Cos\theta}{2\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta - 2L - 2\frac{h_2}{Sin\theta}}$$

c. Position d1 from second bond angle θ



Wire pull distance calculated from the second bond

You can use the same equation to calculate d1 for the second bond by making h2 negative. Φ then becomes θ and d1 is measured from the second bond.

$$d_1 = \frac{\left(\left(\frac{h_2}{Sin\theta}\right)^2 - L^2 + \left(D + \frac{h_2}{\mathrm{Tan}\ \theta}\right)^2 - 2\frac{h_2}{Sin\theta}\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta\right)Cos\theta}{2\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta - 2L - 2\frac{h_2}{Sin\theta}}$$

d. Angle at second bond Φ

The angle at the second bond Φ is derived from this expression.

$$\mathrm{Tan}(\Phi) = \frac{\frac{\left(\left(\frac{h_2}{Sin\theta}\right)^2 - L^2 + \left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)^2 - 2\frac{h_2}{Sin\theta}\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta\right)Sin\theta + h_2}{2\left(D + \frac{h_2}{\mathrm{Tan}\,\theta}\right)Cos\theta - 2L - 2\frac{h_2}{Sin\theta}}}{D - d_1}$$

e. Pull at equal angles

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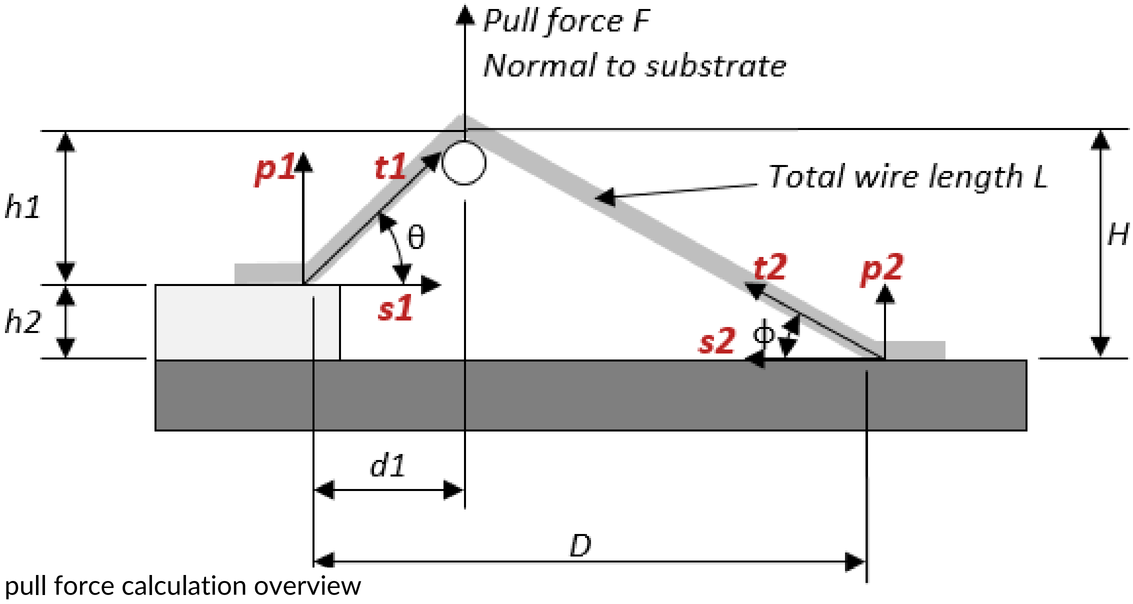
If you want to pull with equal angles (θ=Φ), the following formulas apply.



Wire pull force calculation overview

$$\theta = \Phi = Sin^{-1}\left(\frac{D}{L}\right)$$

$$d_1 = \frac{DSin\theta - h_2Cos\theta}{2Sin\theta}$$

The forces t, p and s then are as follows.

$$t_1 = \frac{FCos\theta}{Sin(\theta+\Phi)}$$

$$p_1 = \frac{FSin\theta Cos\theta}{Sin(\theta+\Phi)}$$

$$p_2 = F - p_1$$

$$s_1 = s_2 = \frac{FCos\theta Cos\theta}{Sin(\theta+\Phi)}$$

$$t_2 = \frac{s_1}{Cos\theta}$$

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