

From Welding Research Council Bulletin 429, in Appendix 4, there is an example of stress linearization of a cylinder to cylinder intersection. The geometry is shown in the figure below. the horizontal section of the geometry is the portion being evaluated. The cylinder being evaluated is 0.1" thick. Stress Classification Lines (SCL) were drawn as shown through the existing node numbers.

Hand calculations were made for SCL #1 where the node numbers are highlighted. Table IV-1 shows the stresses that correspond to node numbers in SCL #1. Table IV-4 shows the results of the membrane and bending stress analysis from the given data.

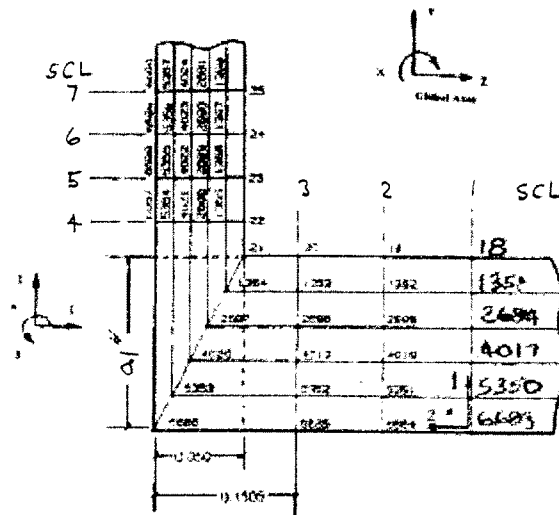


Table IV-1—Tabular Component Stress Distributions (ksi)

	Node	Thickness (11) (ksi)	Hoop (33) (ksi)	Axial (22) (ksi)
SCL 1	6683	-0.038	18.980	13.681
	5350	-0.066	15.464	9.070
	4017	-0.074	11.997	4.509
	2684	-0.052	8.574	-0.027
	1351	0.048	5.197	-4.576
	18	0.108	1.773	-9.292

Table IV-4—Membrane and Bending Stresses (ksi)

	SCL						
	1	2	3	4	5	6	7
Membrane							
Hoop	10.29	13.32	16.77	13.90	10.33	7.50	5.38
Axial	3.24	1.74	1.17	1.19	1.98	2.47	2.23
Bending							
Hoop	8.60	8.19	7.09	4.42	6.33	5.72	5.23
Axial	11.45	10.57	7.98	11.71	17.65	16.37	14.77

Stress linearization has been discussed previously in Eng-Tips at various times. This evaluation is based on the equations from faq794-982, posted May 27, 2004. A method is needed to approximate the curve (straight line) formed by the stresses across the wall thickness. The Simpsons rule is used here. A good explanation of the Simpsons Rule can be found at: <http://www.mactech.com/articles/mactech/Vol.09/09.10/SimpsonsRule/index.html>

The intent of this calculation was to duplicate the bulletin results. Additional processing of stresses may be required to meet allowable stress conditions. Results of the calculations are only shown as absolute values to compare against the bulletin results. The basic equation from the faq converts to:

Integral from a to b $f(x)dx$ is approximately equal to

$$\frac{(b-a)}{(3n)} [f(X0) + 4f(X1) + 2f(X2) + 4f(X3) + 2f(X4) + f(X5)]$$

Where:

b-a = wall thickness

n = number of elements (not nodes) across the wall thickness

X0, etc. = Stress at node as listed in Table IV-1

b := .1 in, Wall thickness

a := 0 Wall surface

n := 5 number of elements across wall

MEMBRANE STRESSES

Basic equation from
Eng-Tip faq:

$$\sigma_{im} := \frac{\left(\int_a^b \sigma_i da \right)}{t}$$

Membrane Hoop Stress at SCL #1

$$\sigma_{mhl} := \frac{(b-a)}{3 \cdot n} \cdot (18.98 + 4 \cdot 15.464 + 2 \cdot 11.997 + 4 \cdot 8.574 + 2 \cdot 5.197 + 1.773)$$

$$\sigma_{mh} := \frac{\sigma_{mhl}}{b} \quad |\sigma_{mh}| = 10.086 \quad \text{ksi, Membrane hoop stress, approx} = 10.29 \text{ from Table IV-4}$$

Membrane Axial Stress at SCL #1

$$\sigma_{mal} := \frac{(b-a)}{3 \cdot n} \cdot [13.681 + 4 \cdot 9.07 + 2 \cdot 5.509 + 4 \cdot (-.027) + 2 \cdot (-4.576) + (-9.292)]$$

$$\sigma_{ma} := \frac{\sigma_{mal}}{b} \quad |\sigma_{ma}| = 2.828 \quad \text{ksi, Membrane axial stress, approx} = 2.24 \text{ from Table IV-4}$$

BENDING STRESSES

Basic equation from
Eng-Tip faq:

$$\sigma_{im} := \frac{\left[\int \left(\sigma_i(x) - \frac{t}{2} \right) dx \right]}{\frac{t^2}{6}}$$

Where x= distance from wall surface to node number

Bending Hoop Stress at SCL #1

Calculate moment arms to each node:

$$d0 := 0 - \frac{1}{2} \quad d1 := \frac{b}{n} - \frac{b}{2} \quad d2 := 2 \cdot \frac{b}{n} - \frac{b}{2}$$

$$d3 := 3 \cdot \frac{b}{n} - \frac{b}{2} \quad d4 := 4 \cdot \frac{b}{n} - \frac{b}{2} \quad d5 := 5 \cdot \frac{b}{n} - \frac{b}{2}$$

$$\sigma_{bh1} := \frac{(b-a)}{3 \cdot n} \cdot (18.98 \cdot d0 + 4 \cdot 15.464 \cdot d1 + 2 \cdot 11.997 \cdot d2 + 4 \cdot 8.574 \cdot d3 + 2 \cdot 5.197 \cdot d4 + 1.773 \cdot d5)$$

$$\sigma_{bh} := \frac{\sigma_{bh1} \cdot 6}{b^2} \quad |\sigma_{bh}| = 9.205 \quad \text{ksi, Bending hoop stress, approx} = 8.6 \text{ from Table IV-4}$$

Bending Axial Stress at SCL #1

$$\sigma_{ba1} := \frac{(b-a)}{3 \cdot n} \cdot [13.681 \cdot d0 + 4 \cdot 9.07 \cdot d1 + 2 \cdot 5.509 \cdot d2 + 4 \cdot (-0.027) \cdot d3 + 2 \cdot (-4.576) \cdot d4 + (-9.292) \cdot d5]$$

$$\sigma_{ba} := \frac{\sigma_{ba1} \cdot 6}{b^2} \quad |\sigma_{ba}| = 10.491 \quad \text{ksi, Bending axial stress, approx} = 11.48 \text{ from Table IV-4}$$