2.5-1

**Strategy**: Assuming the welds have no "give"... the thermal strain must be exactly canceled out by compressive strain.

\[ \varepsilon_T = \varepsilon_c \]

and \[ \varepsilon_T = \alpha \Delta T \] and \[ \varepsilon = \frac{\sigma}{E} \]

so... let's do it...-

**Solution**:

\[ \alpha \Delta T = \frac{\sigma}{E} \quad \Rightarrow \quad \sigma = \alpha \Delta T E \]

\[ \sigma = 6.5 \times 10^{-6} \ \text{in/in} \times (120 - 60) \ \text{F} = 30 \times 10^6 \ \text{psi} \]

\[ \sigma = 11,700 \ \text{psi} \]

**Yikes**

**Answer**: 11.7 ksi Compression...

**Discussion**: We could have also brought in \( L \), either generic, or in some actual number, but it would cancel out...
2.5-3 ...

**Strategy:** ... this could be a hard problem, a very much statically indeterminate problem ... except that the author gives us the condition that all the load is carried by the steel wires at some particular temperature. So, in *this condition* ... it is statically determinate ... all the forces go to the steel. So, here we go ...

\[
delta \text{ for the steel wires} = \delta_{\text{load}} + \delta_{\text{temp}}
\]

\[
delta \text{ for the alum wire} = \delta_{\text{temp}} \text{ only}
\]

and ...

all these deltas are equal ...

**Solution:** let's do it ...

**Steel ...**

Load divides equally to the two steel wires ... \( T = 750 \text{ lb} / 2 \) each = 375 lb each.

\[
\ldots \delta_{\text{steel}} = \frac{PL}{AE} + \alpha x \Delta T x L =
\]

\( L = ? \ldots \) I hope it cancels out ...

\[
A = \pi D^2 / 4 = 3.14 (\text{.125 in.})^2 / 4 = .01227 \text{ in.}^2
\]

So, ...

\[
\ldots \delta_{\text{steel}} = 375 \text{ lb} \times L / (0.01227 \text{ in.}^2 \times 30,000,000 \text{ lb/in.}^2) + 6.5 \times 10^{-6} \Delta T \times L \text{ per deg F}
\]

**Alum ...**

\[
\ldots \delta_{\text{alum}} = \alpha \Delta T \times L = 12 \times 10^{-6} \Delta T \times L \text{ per deg F}
\]

and the deltas are equal ... and the L's do cancel ...

\[
0.001019 \text{ L} + 6.5 \times 10^{-6} \Delta T \times L \text{ per deg F} = 12 \times 10^{-6} \Delta T \times L \text{ per deg F} 
\]

\[
0.001019 = 5.5 \times 10^{-6} \Delta T \text{ per deg F}
\]

\[
\Delta T = 185 \text{ deg F.}
\]

**Answer:** ... 185 deg F (increase)
Discussion: could you solve this for a condition for which there is still some stress in the aluminum? ... It would be no longer statically determinate ... but you could still solve the problem! ... It might not be super easy ... but you could do it. Perhaps in closed form? ... or by trial and error.
Strategy: ... easy ... let's calc the delta we get with the temperature rise, and if it more than closes the gap, we'll calculate the stress needed to compress it back so that it just fits.

Solution: ...

delta due to Temp ... = $9.6 \times 10^{-6}$ in./in.deg F x 50 deg F x 25 in. = 0.012 in. Dang! ... it closed the gap, and tried to go farther ... 0.004 in. farther, to be exact ...

Well ... how much stress do we need to compress it back? ...

strain it back ...

$0.004 \text{ in.} / 24 \text{ in.} = \text{strain} = 0.00016 \text{ in./in.}$

and ...

$E = \text{sigma} / \text{strain} ... \text{so sigma} = E \times \text{strain} ... = 0.00016 \text{ in./in.} \times 16 \times 10^6 \text{ psi per in./in.} ...$

sigma = 2560 psi.

Answer: sigma = 2560 psi (2600 psi).

Done!