Residual strain measurement, Lehigh University (June 1954)

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The procedure outlined below applies to essentially uniaxial type of stresses as present in long slender members (beams, columns). The 10" Whittemore strain gage has been used in the past. The same procedure outlined below can be applied to an instrument of 2" gage length.

1. Selection

If cooling residual stresses are to be measured, make certain that the region to be cut is completely clear of cold-bend yield lines.

2. Layout of Holes

A minimum number of holes for a satisfactory indication of residual stresses in a WF shape is indicated below (the same system of designation has been used on all previous tests).
3. Preparation of Holes

Use drill No. 57+ or \( \frac{3}{64}^\circ \), holes shall be reamed (reamer angle 60°). The reamed depth should be equal for all holes (0.005" - 0.01").

After this operation clean holes with carbon tetrachloride and air-blast.

4. Measuring Technique

Attach standard bar of mild steel to steel surface to be measured ahead of time (at least 1 hr.). Avoid measurements in sunlight or draft, this will result in inaccurate readings.

It is important to get a good set of initial readings since they cannot be duplicated later on.

The gage should be used in horizontal position whenever possible since this will give best results. Apply little and even pressure when inserting the gage in the holes. (If possible, it is better to use some kind of supporting arm which will maintain gage perpendicular to the surface of specimen.) It is important to measure later on the gage lengths and standard bar with the same relative position of the measuring gage. When measuring take at least three separate readings (if the change between them is less than \( \frac{1}{10,000} \)) or more (if variations are a little bit larger it is advisable to ream and to make hole clean again) and write down the average only. If there is too much variation between readings there is either dirt in the hole or it is uneven and needs more reaming.
The gage points should be wiped frequently with a clean cloth. Also standard bar readings should be taken after 5 to 10 gage readings.

After initial readings have been taken the section may be cut out of the beam and marked on the face which is pointing to the near end (see sketch above). Before the specimen is cut it is advisable to cover all gage holes with tape to keep dirt out and avoid damage. It is not necessary to cut all of the section into small strips, a separation by saw cuts as shown above is usually satisfactory.

5. Evaluation of Data

Let $R_1$ and $R_{t1}$ be the initial readings on a pair of holes and on the standard bar respectively. $R_2$ and $R_{t2}$ be the final readings. The residual stress is then calculated by the following formula:

$$\sigma_r = E \varepsilon_r = \frac{E}{L} \left[ (R_1 - R_2) - (R_{t1} - R_{t2}) \right]$$

where $E$ is the elastic modulus, $L$ the gage length.