

## Gage Factor and Transverse Sensitivity Effects

- The gage factor ( $S_g$ ) and transverse sensitivity coefficient ( $K_t$ ) are two strain gage calibration constants *measured by the gage manufacturer* and provided to the user.
- $S_g$  and  $K_t$  are measured in accordance with ASTM E251-92
- Note: The gage factor ( $S_g$ ) is often confused with the strain sensitivity of the gage alloy ( $S_A$ ):

$$S_A = \frac{\left(\frac{\Delta R}{R}\right)}{\varepsilon}$$

(as will be seen, this confusion occurs for a very good reason...!)

## Measurement of the Gage Factor

- Several gages from a lot of gages are bonded to a constant stress cantilever beam described in the E251 standard and made from a standard calibration material (normally 1018 steel).
- Specimen design and loading frame allows both tensile and compressive stress/strains to be easily applied

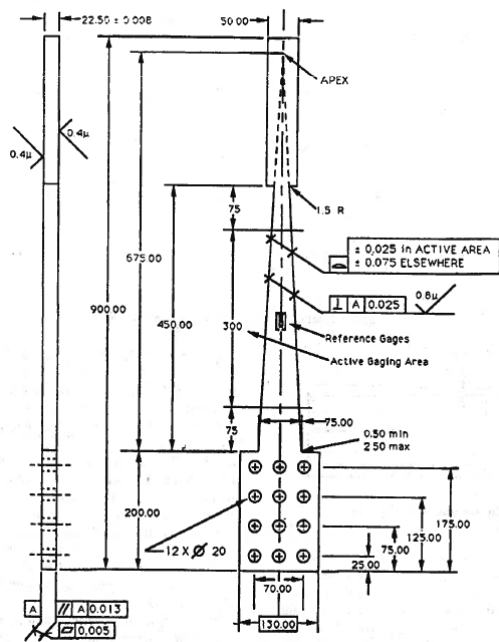


FIG. 6 Constant Stress Cantilever Beam

Sketch of constant stress beam  
(from ASTM E251-92)

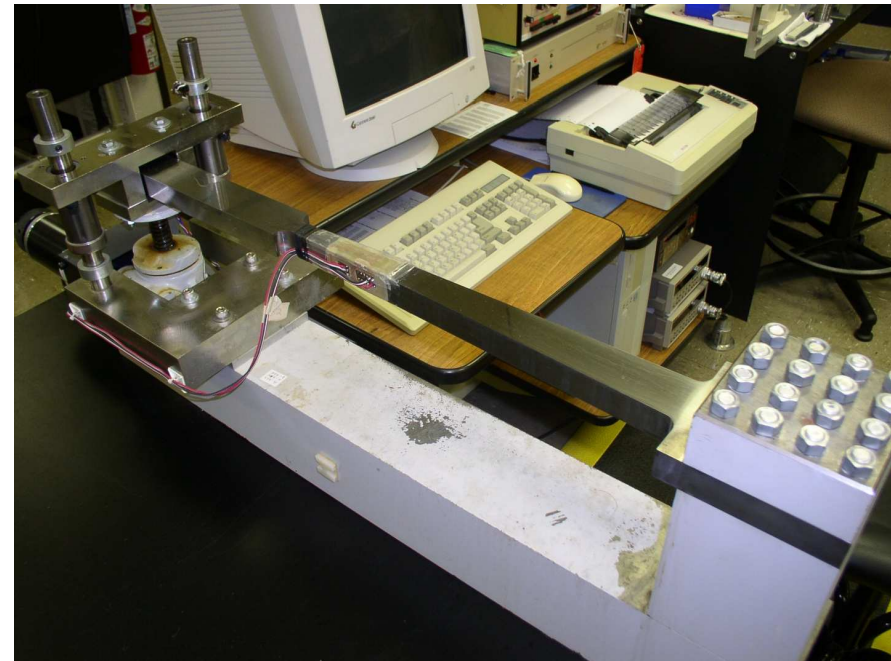


Photo courtesy Becky Showalter, M-M Group

## Measurement of the Gage Factor (cont'd)

- Initial resistance is measured ( $R$ )
- Stress is increased until an axial strain  $\epsilon = \pm 1000 \mu\epsilon$  is induced at gage site (i.e., separate tensile and compressive tests are conducted)
- Corresponding change in resistance is measured ( $\Delta R$ )
- Gage factor calculated: 
$$S_g = \frac{(\Delta R/R)}{\epsilon}$$
- Measurement repeated for several gages; average and tolerance provided to user
- Suppose a constantan gage is used. Would you expect the gage factor for a constantan gage to differ from the strain sensitivity of the constantan alloy?

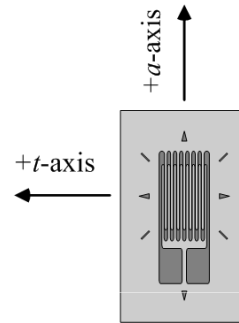
Recall: 
$$S_A = \frac{(\Delta R/R)}{\epsilon}$$

## Measurement of the Gage Factor (cont'd)

- During measurement of  $S_A$  the constantan wire is subjected to a uniaxial stress and allowed to contract “naturally” (i.e., according to the Poisson ratio of constantan,  $\nu_{const}$ )
- During measurement of  $S_g$  the calibration material is subjected to a uniaxial stress, and the constantan foil gage bonded to the test specimen is forced to contract according to the Poisson ratio of the calibration material,  $\nu_o$  (Poisson ratio of 1018 steel is 0.285)
- So, if the resistance of the constantan gage changes due to transverse strain, then  $S_g \neq S_A$  (....unless  $\nu_o = \nu_{const}$  ....)

## Significance of the Transverse Sensitivity Coefficient

- Given: a strain gage subjected to in-plane strains referenced to the  $a$ - $t$  coordinate system:  $\epsilon_a$ ,  $\epsilon_t$ ,  $\gamma_{at}$



- Define three types of strain gage strain sensitivities

$$S_a = \text{axial strain sensitivity} = (\Delta R/R)/\epsilon_a$$

$$S_t = \text{transverse strain sensitivity} = (\Delta R/R)/\epsilon_t$$

$$S_s = \text{shear strain sensitivity} = (\Delta R/R)/\gamma_{at}$$

## Significance of the Transverse Sensitivity Coefficient

- Assuming gage alloys exhibits linear strain sensitivities, principle of superposition applies:

$$\frac{\Delta R}{R} = S_a \epsilon_a + S_t \epsilon_t + S_s \gamma_{at} \quad (6.4)$$

- Experimental measurements show:

$$S_s = \text{shear strain sensitivity} = 0$$

- Define the transverse sensitivity coefficient:  $K_t = S_t/S_a$

Eq (6.4) becomes:

$$\frac{\Delta R}{R} = S_a (\epsilon_a + K_t \epsilon_t) \quad (6.5)$$

## Significance of the Transverse Sensitivity Coefficient

- During measurement of the  $S_g$ :

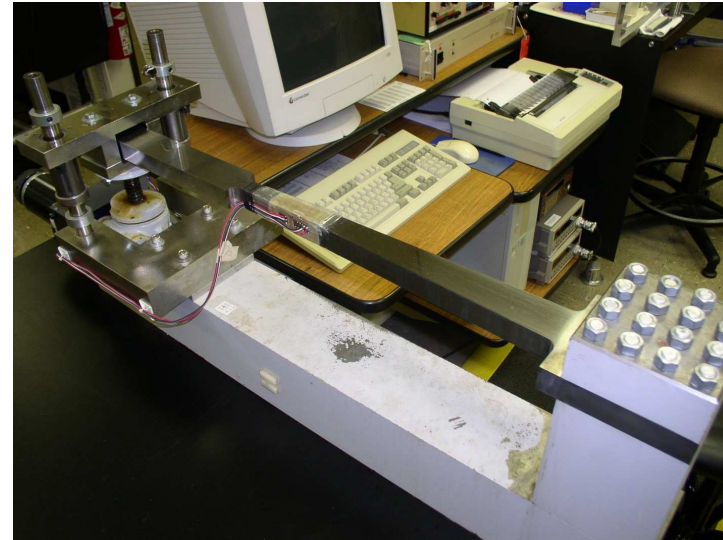
$$\epsilon_t = -\nu_o \epsilon_a$$

- According to Eq (6.5) then:

$$\frac{\Delta R}{R} = S_a (1 - \nu_o K_t) \epsilon_a$$

- Therefore:

$$S_g = \frac{\left(\frac{\Delta R}{R}\right)}{\epsilon_a} = S_a (1 - \nu_o K_t)$$



## Measurement of the Transverse Sensitivity Coefficient

- $K_t$  is measured using a special fixture that induces an (in-plane) uniaxial *strain* field (described in ASTM E251 standard)
- Separate gages oriented to measure
  - Axial strain:  $S_a = (\Delta R/R)/\epsilon_a$
  - Transverse strain:  $S_t = (\Delta R/R)/\epsilon_t$
  - $K_t = S_t/S_a$

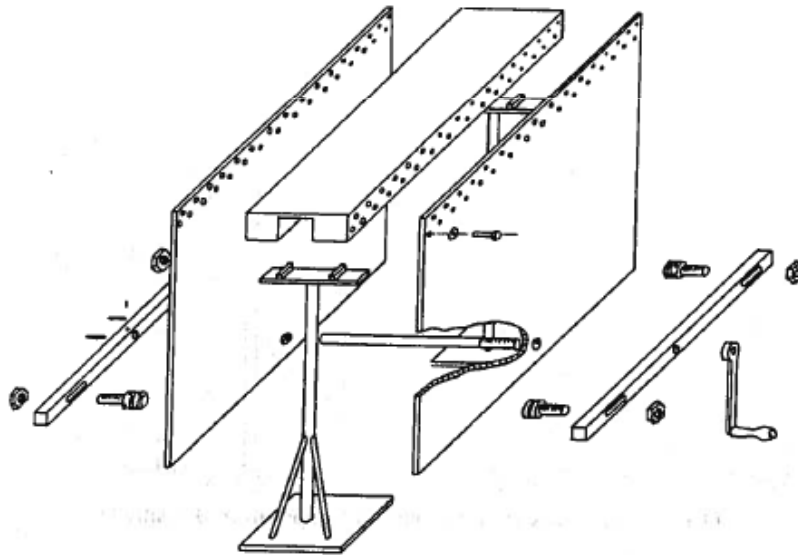


FIG. 14 Transverse-Sensitivity Test Rig

Sketch of transverse sensitivity test rig  
(from ASTM E251-92)



Photo courtesy Becky Showalter, M-M Group

## Measurement of the Transverse Sensitivity Coefficient

- Transverse sensitivity is an undesirable effect...gage manufacturers have successfully minimized (but not eliminated) this phenomenon

**Table 6.3**

**Gage factor  $S_g$ , axial sensitivity  $S_a$ , transverse sensitivity  $S_t$ , and transverse-sensitivity factor  $K_t$  for several different foil-type strain gages.**

Gage Designation	$S_g$	$S_a$	$S_t$	$K_t$ (%)
EA-06-015CK-120	2.13	2.14	0.0385	1.8
EA-06-030TU-120	2.02	2.03	0.0244	1.2
WK-06-030TU-350	1.98	1.98	0.0040	0.2
EA-06-062DY-120	2.03	2.04	0.0286	1.4
WK-06-062DY-350	1.96	1.96	-0.0098	-0.5
EA-06-125RA-120	2.06	2.07	0.0228	1.1
WK-06-125RA-350	1.99	1.98	-0.0297	-1.5
EA-06-250BG-120	2.11	2.11	0.0084	0.4
WA-06-250BG-120	2.10	2.10	-0.0063	-0.3
WK-06-250BG-350	2.05	2.03	-0.0690	-3.4
WK-06-250BF-1000	2.07	2.06	-0.0453	-2.2
EA-06-500AF-120	2.09	2.09	0.0	0
WK-06-500AF-350	2.04	1.99	-0.1831	-9.2
WK-06-500BH-350	2.05	2.01	-0.1347	-6.7
WK-06-500BL-1000	2.06	2.03	-0.0893	-4.4

\*This data is approximate as the values depend on the lot of foil used in gage fabrication.