STANDARD OPERATING PROCEDURE (S.O.P.)

SOP-55-029-06
ORIGINAL

TITLE: TEST FRAME ALIGNMENT

APPROBATION	**2006-04-18**
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TEST FRAME ALIGNMENT

1.0 Scope and application

It has been shown that bending stresses that inadvertently occur due to misalignment between the applied force and the specimen axes during tensile forces can affect the test results.

This document describes a method for verifying the machine alignment by means of measuring the bending on the surface of a strain-gauged specimen.

An Excel file named "Alignment_round.xls" is available on the : Network \\Tech_nt2\E\P-C_Departement\Metallurgie\Alignment to perform the bending calculations for round specimens once the individual strain readings are entered. Explanations about how the calculus is done are in section 8 of this document. Use this file in performing alignments. A validation for the calculations for the above file is available.

2.0 References

ASTM E1012: Standard Practice for Verification of Specimen Alignment under Tensile Loading

3.0 Personnel Qualification

Only operators with suitable documented training are allowed to perform evaluation according to this procedure.
The operator must demonstrate minimum category 2 of competence and the test has to be supervised by an engineer. An experienced supervisor or manager must verify results.

4.0 Hazards and safety measures

The hazard and safety measure corresponding to the machine being aligned.

5.0 Apparatus

- Strain gage conditioner
- Calibrated multimeter
- Shunt device

- Strain reader
- Alignment specimen with strain sensors

6.0 Alignment Specimen

6.1 Alignment checks should be carried out on samples manufactured for that purpose and not on the specimens to be used as test samples.

6.2 It is preferable that the gage length of the alignment specimen is the same as the sample to be tested but may be increased in length for convenience.

6.3 A high yield strength material should be used for alignment specimens. It is desirable to verify alignment over the full load range that is used for testing. Where this means the alignment specimen would be taken to max. 60% of the 0.2% yield stress then a sample with an enlarged cross section may be used. It must be remembered however, that the bending stress induced by misalignment will be inversely proportional to the section modulus. This means the bending stress observed will be reduced by a factor of 4 if the gage diameter is doubled.

6.4 Account must be taken of this reduced sensitivity when accessing the results of a check. Under no circumstances should an alignment specimen diameter exceed twice that of a standard sample. A regular standard round sample is 0.5" diameter as per ASTM E8 and this size is usually tested in the lab.

6.5 Samples should be machined to the same tolerances, concentricity and finish as the normal specimens. They must be clearly identified as alignment samples and must be held securely by a responsible who can supervise their use and ensure they are not loaded to beyond 60% of their yield stress.

6.6 The alignment cell may be of a cylindrical or rectangular type. It should fit into the machine grips / adapters in the same way as the test specimen, so that use of special adapters is avoided.

6.7 It is recommended that the gauge is as small as practically possible in order to minimise any effects due to strain averaging. All strain gauges used should be from the same batch. The gauges are to be arranged in two sets of four with each set mounted on one of two strain measurement planes as per ASTM E1012. The distance between these planes should be 0.75 of the gage length to avoid interaction of the strain gauges with stress concentration effects associated with the change of section at the ends of the specimens' parallel length. Strain gauges 1,2,3 and 4 are to be in one plane and strain gauges 5,6,7, and 8 in the other plane (as per ASTM E1012).

7.0 Procedure

7.1 Cary out any preliminary adjustments using appropriate means to reduce any misalignment in the machines' load train.

7.2 Connect the lead wires of the strain gauges to the conditioning equipment and allow the system to equilibrate under power for at least 30 minutes prior to making any readings. To validate the strain readings, do the shunt verification as follows:

Connect in parallel to a strain gage mounted on the specimen (value of 350 ohm) the following resistors to obtain the following strain readings:

RESISTANCE (OHM)	STRAIN (µSTRAIN)	STRAIN READ (µSTRAIN)	ERROR (%)
174650	1000		
87150	2000		
34650	5000		

Different values of strain gage resistances will require different resistance to shunt with above.

The table above has to be used while performing this verification. The third and the fourth column are reserved for the obtained values. The resistances have to be measured with a calibrated multimeter (ohmmeter). A potentiometric set-up can be used to match the values above. The errors obtained have to be below 1%.

Error = 100 x (strain – strain read)/strain

7.3 Set up so that gauges 1 to 4 are closest to the upper grip and conveniently aligned with the alignment fixture, i.e. gauge 1 aligned with 0° of the fixture for a round specimen. By convention, 0° orientation will be always with the strain gage 1 toward the operator.

7.4 Zero the strain gauges. This is an operation to be done always at zero load. Reset the load reading. At this moment the load has to show zero.

7.5 Grip the other end of the alignment cell in the lower grip interface and with the machine at zero force, record the strain readings.

7.6 Load and unload three to five times to the nominal load (see 7.7 for value and load rate). No data recording is necessary at this stage.

7.7 Record in the Excel file at "initial values" the 8 values of the strain given by the strain gages at zero force. These values have to be zero or not far from zero, otherwise check the setup and the strain gaged specimen; replace whatever component is necessary and re start the procedure. Apply the maximum load (approximately 60 % of the specimen Yield 0.2%) and record in the Excel file at "final values" the 8 values of the strain from the strain sensors. The maximum load has to be applied gradually, in minimum 10 seconds (recommended 20 seconds). Record the eight readings in Excel file at "final values".

Excel calculates the % bending for this orientation. If not within the target value of maximum 8 % for brittle materials or maximum 10% for ductile materials, adjust the alignment fixture and repeat the test. Changes and/or repairs of the load train components may be necessary for adjustment.

7.8 Repeat the test several times by taking the alignment strain gauged specimen completely out of the grips[1] and rotating it 90° four times counter-clockwise (i.e. start at 0°, 90°, 180°, 270°, back to 0°). Use the same load as in 7.7 and take a new set of readings. The Excel file will calculate the percentage bending for each orientation and the average.

7.9 If the alignment fails, adjust the load train as per 7.7 until satisfactory.

7.10 Once a satisfactory alignment has been achieved, perform a repeatability study by applying the maximum load (as in section 7.7) and unloading to 10% of maximum load. Repeat 5 times on the same orientation and record the strain values. Calculate the maximum bending and perform a repeatability study.

8.0 Calculations and reporting

This section describes how the Excel file "Alignment_round.xls" calculates the results.

The following equations describe calculations for the upper plane of the alignment specimen strain gages 1, 2, 3 and 4. This was done to reduce repetitive equations. Therefore, the equations presented in 8.1. to 8.4 are also applicable to the second plane (strain gages 5, 6, 7, and 8).

8.1 Axial strain

Calculate the axial strain a, for each orientation, as follows:

$a_{0°} = (e_1 + e_2 + e_3 + e_4) / 4$

and repeat for $a_{90°}$, $a_{180°}$, $a_{270°}$, and again $a_{0°}$

Where e_1, e_2, e_3 and e_4 are the measured strains at the four strain locations.

The measured strain = final value (at nominal force) – initial value (at zero force).

[1] Also disassemble and reassemble the load train before each load run.

8.2 Local bending

Local bending = strain – axial strain, as follows:

$b_{1,0°} = e_{1,0°} - a_{0°}$

$b_{2,0°} = e_{2,0°} - a_{0°}$

$b_{3,0°} = e_{3,0°} - a_{0°}$

$b_{4,0°} = e_{4,0°} - a_{0°}$

Obtain the other local bending as per above for each strain gauges at the other orientations (90°, 180°, 270°, and again 0°)

8.3 Maximum bending strain

$B_{max} = \frac{1}{2}\sqrt{(b_1 - b_3)^2 + (b_2 - b_4)^2}$

8.4 Maximum percent bending

$ß = abs \mid B_{max} / a_{avg} \mid x\ 100$

where B_{max} is calculated using equation in section 8.3 and a is the axial strain in section 8.1

8.5 Average Bending percent for both planes where the strain gages are installed

$B_{ave} = (ß(\text{plane } 1) + ß(\text{plane } 2)) / 2$

9.0 Report

The alignment report must include the following:

- Operator name and date of verification
- Method used
- Drawing showing locations of strain sensors on specimen. (Can be replaced by a photo with a brief description.)
- Description of the specimen (material and dimensions)

- Test temperature
- Rated maximum load used in verification and load rate used.
- Description of strain measuring equipment, including precision and sensitivity and method of fastening strain sensors to the specimen
- Description of test machine. load-train, including method of gripping, dimensions of pull bars, types of couplings and joints, and length of load-train
- Five sets of values as follows: one per orientation at 0°, 90°, 180°, 270°, 0° again.
- Values of bending or percent bending, excel print-out of calculations
- Sample calculation, if calculated manually
- Statement of conformance or non-conformance.
- Statement that strain gauges met repeatability in 5 loadings.

10.0 History of Revision

Original (2006-04-18) the first issue.