Alignment Calibration

Does Alignment Affect My Testing?

Probably - YES

It would be wrong to think that just because your materials testing system is regularly calibrated for force, strain and displacement that you are assured correct and reliable materials testing data. Load frame alignment can change for a number of reasons, including:

- Changing grips
- Fitting new or replacement fixtures
- Repositioning the fixed cross head
- Wear or damage to fixtures or load frame components

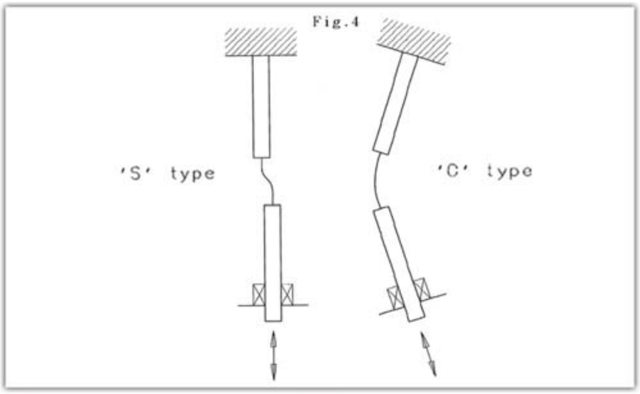
As a consequence, the importance of accurate alignment is being recognized more and more by:

- Accreditation bodies
- Major aerospace corporations

There is a growing requirement in the aerospace industry to demonstrate that your systems meet the alignment requirements specified in many ASTM standards that reference tolerances for either bending stresses or alignment.

What is Alignment?

- Concentricity
- Angularity (parallelism)



Why is Good Alignment Necessary?

The easiest way to put unwanted stresses into a test piece is to bend it. The easiest way to bend it is to misalign it initially and/or load it non-uniformly by:

- Application of an angular offset - C type bending
- Application of a concentricity offset - S type bending

Many standards specify quality of testing in terms of % bending, e.g.< 5% of nominal strain or of strain amplitude (see next page).

ASTM Standards with Alignment Requirments

Test	Standard	Maximum Allowed Bending	Measurement Location
High temperature tensile tests on metallic materials verification test piece	ASTM E 21-92	10%	At either end of the parallel section in two orientations of a verification test piece
Creep, creep rupture and stress rupture	ASTM E 139	10%	At either end of the parallel section in two orientations of a verification test piece
Time-for-rupture notch tension	ASTM E 292	10%	Center of the parallel section of a verification test piece
Sharp notch tension testing	ASTM E 602	10%	Center of parallel section and in different orientations of a verification test piece
Creep and rupture testing of metals	BS 3500	10%	Unspecified
Tensile testing of high performance ceramics at room and elevated temperature	JIS R 1606	10%	Center of parallel section of circular cross section test piece
Creep and creep rupture under rapid heating	ASTM E 150	7.5%	———
Stress relaxation tests in tension	ASTM E 328	7.5%	———
Stress relaxation tests in compression	ASTM E 328	5%	———
Constant amplitude axial fatigue tests	ASTM E 466	5%	At either end of the parallel section of a verification test piece or of the actual test piece
Constant amplitude LCF	ASTM E 606	5%	At either end of the parallel section of a verification test piece
Tensile tests on monolithic ceramics	ASTM C 1273-94	5%	At either end of the parallel section and in four orientations of a verification test piece, either a dummy or an actual test piece
Tensile tests on continuous fiber reinforced ceramic matrix composites	ASTM C1274-94	5%	At either end of the parallel section and in four orientations of a verification test piece, either a dummy or an actual test piece
Axial strain controlled low cycle fatigue	ISO/TC164/ SC5/WG2/N1	5%	In one of the three instrumented planes of a verification test piece
Fatigue crack growth	ISO/TC164/ SC5/WG6/N3	5%	In one of the three instrumented planes of a verification test piece
Constant amplitude LCF at high temperatures	HTMTC code of practice	5%	At either end of the parallel section and in different orientations of a verification test test piece
Elastic, tangent and chord modulus	ASTM E 111	3%	Unspecified
Constant amplitude strain controlled fatigue	BS 7270	2%	Unspecified
High temperature tensile tests on metallic materials	EN 10002-5	———	Verification recommended according to ASTM E 1012
Low cycle fatigue	NFA 03403	10%	Unspecified
Tension and compression testing of ceramic matrix composites	ENV 658	———	Verification recommended according to ASTM E 1012

Courtesy HTMTC Code of Practice 1995

Alignment Verification Certificate

CERTIFICATE OF CALIBRATION
Issued by: INSTRON CALIBRATION LABORATORY

Date of Issue: **1-Feb-2006** Certificate No: **E123456**

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Approved Signatory
D.J.Willmott

Customer: High Technology Alloys Plc
123 Satellite Avenue
Rocket City
Rosshire RU1 4ME
United Kingdom

Contact: Buzz Lightyear Date of Verification: 31-Jan-2006

Machine		**Grip & Specimen Configuration**	
Manufacturer:	Instron	Grip Type;	2716-321
Model:	6025	Description:	Wedge Action Grips
Serial No:	6025 H1234	Grip capacity:	100kN
Type:	Electro-mechanical		
Capacity:	100kN		
Year of Manufacture:	1982		

Measuring Instrumentation

Instrument ID:	AP-USB-350-01[A]	Specimen Identification:	Flat Thin 8000-174 S/N 0001
Description:	16 Bit Multi-channel Strain gauge conditioner Unit	Description:	Thin Rectangular - 8 Gauge
		Specimen parameters:	see Fig 2 (Page 4)

Method of Verification

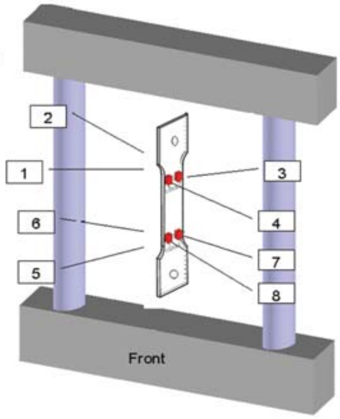
The above machine and gripping system was fitted with a thin flat specimen configured with 2 sets of 4 strain gauge sensors meeting the requirements of ASTM E1012-05. A photograph showing the machine and gripping configuration is shown in Fig 3

The strain gauged alignment specimen was placed into the machine's grip system and loaded to a force agreed with the customer that was within the elastic range of the specimen. Readings from the set of eight strain gauges were then recorded. The specimen was then unloaded. The specimen was then reloaded a further 5 times to provide 6 sets of strain gauge reading data.

The specimen was then rotated through 180 degrees and subjected to a repeat loading and recording cycle to produce a further 6 sets of data.

The data was then computed using the equations provided by ASTM E1012 to provide Bending Strain and Percent Bending results as shown in the results section later in this certificate.

The computed data provides information on bending strains resulting from the alignment of the machine and grip string. The repeating of the tests 6 times provides information on the variability of such bending strains from one test to another.



Schematic diagram showing configuration of machine and strain gauged specimen

Instron® certificates are designed to help you meet your quality program requirements. All of them include a unique certificate number and date of issue.

The report of the work is checked and verified by an approved signatory.

Procedure is applicable to any system and complete description of the machine eliminates all doubts about what has been verified.

A detailed scope of the method of verification is defined.

Alignment Verification Certificate

The certificate number is printed on every page for quick reference.

CERTIFICATE OF CALIBRATION

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Results

Temperature during the calibration:	Start:	20.4 °C	Specimen width, W:	15 mm
	Finish:	21.4 °C	Gauge inset, d:	2.5 mm

Strain data in units of microstrain

Top mounted Gauges **Applied Force: 8 kN**

Applied Force	Run No.	ASTM E1012 calculations: Gauge 1 facing Front of the machine				Gauge 1 facing Back of the machine			
		G1	G2	G3	G4	G1	G2	G3	G4
8kN	1	1414.20	1307.75	1287.18	1399.79	1330.60	1351.73	1370.59	1341.90
	2	1389.79	1280.14	1277.49	1401.80	1382.98	1314.19	1301.49	1392.61
	3	1423.10	1298.07	1278.19	1392.00	1379.46	1294.08	1285.96	1375.07
	4	1418.68	1298.92	1299.86	1422.24	1413.95	1308.49	1303.09	1406.12
	5	1407.21	1275.78	1272.37	1421.68	1387.42	1284.37	1289.22	1413.63
	6	1408.76	1288.23	1278.92	1417.12	1396.16	1309.68	1288.82	1409.13

Run No.	Data corrected for Alignment cell variation: G1 corrected	G2 corrected	G3 corrected	G4 corrected
1	1392.39	1324.83	1308.98	1382.71
2	1345.64	1336.37	1321.64	1345.57
3	1354.53	1336.57	1346.76	1353.50
4	1360.88	1352.52	1357.66	1368.64
5	1348.22	1344.70	1331.37	1352.75
6	1348.79	1348.68	1338.90	1356.67

Run No.	Axial Strain (a)	Local Bending Strain for Gauges 1 ~ 4: b1	b2	b3	b4	Max Bending Strain (B)	Percent Bending (PB)
1	1352.23	52.99	6.38	-52.99	-6.38	59.37	4.39
2	1337.31	12.45	3.70	-12.45	-3.70	16.15	1.21
3	1347.84	9.26	-2.29	-9.26	2.29	11.55	0.86
4	1359.92	7.26	-3.22	-7.26	3.22	10.48	0.77
5	1344.26	9.34	2.20	-9.34	-2.20	11.54	0.86
6	1348.26	6.71	0.48	-6.71	-0.48	7.18	0.53

Mean Percent Bending (PB): 1.44 %

Standard Deviation of PB: 1.46 %

The procedure provides multiple runs to give sufficient information to determine repeatability and spread of results.

Base mounted Gauges **Applied Force: 8 kN**

Applied Force	Run No.	ASTM E1012 calculations: Gauge 1 facing Front of the machine				Gauge 1 facing Back of the machine			
		G5	G6	G7	G8	G5	G6	G7	G8
8kN	1	1456.77	1457.83	1249.10	1247.82	1357.87	1462.59	1326.04	1246.87
	2	1436.40	1408.17	1239.14	1277.08	1433.79	1449.08	1250.75	1272.32
	3	1441.15	1432.12	1251.94	1283.03	1441.37	1398.03	1225.90	1294.03
	4	1453.17	1433.92	1264.07	1302.90	1458.34	1431.64	1243.87	1309.04
	5	1453.07	1417.40	1237.63	1281.15	1472.77	1419.77	1226.97	1285.02
	6	1438.97	1418.31	1247.10	1291.28	1452.45	1420.18	1242.15	1301.21

Run No.	Data corrected for Alignment cell variation: G1 corrected	G2 corrected	G3 corrected	G4 corrected
1	1391.40	1352.35	1314.46	1353.30
2	1343.58	1340.24	1331.97	1345.00
3	1333.53	1363.07	1359.57	1352.07
4	1348.52	1371.48	1368.72	1365.34
5	1340.02	1351.21	1350.68	1347.34
6	1340.56	1359.76	1345.51	1349.84

Run No.	Axial Strain (a)	Local Bending Strain for Gauges 1 ~ 4: b1	b2	b3	b4	Max Bending Strain (B)	Percent Bending (PB)
1	1352.88	29.21	19.00	-29.21	-19.00	48.21	3.56
2	1340.20	6.13	1.71	-6.13	-1.71	7.85	0.59
3	1352.06	-13.89	-3.76	13.89	3.76	17.65	1.31
4	1363.52	-9.88	-3.52	9.88	3.52	13.39	0.98
5	1347.31	-5.45	-1.70	5.45	1.70	7.14	0.53
6	1348.92	-5.58	1.24	5.58	-1.24	6.82	0.51

Mean Percent Bending (PB): 1.25 %

Standard Deviation of PB: 1.18 %

Calibrator: Colin Easden

Alignment Verification Certificate

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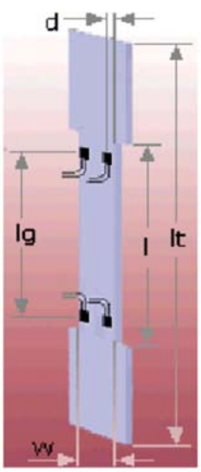
Specimen & Machine details

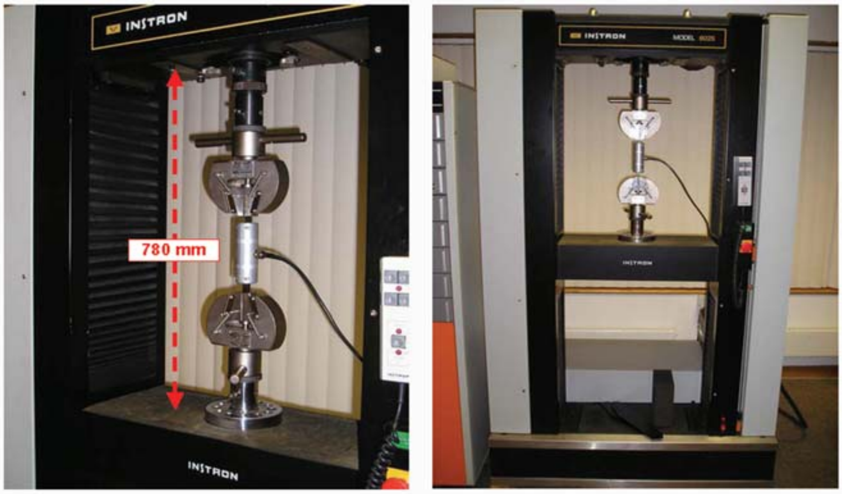
Figure 2 details the strain gauged specimen used during these measurements

Specimen Identification:		Flat Thin 8000-174 S/N 0001	
Specimen Description:		Thin Rectangular - 8 Gauge	
Material:		Steel	
Alignment load:		8 kN	
Dimensions:	Total length (lt):	213	mm
	Width (W):	15	mm
	Length (l):	60	mm
	Distance (d):	2.5	mm
Gauges:	No. off:	8	
	Gauge Factor:	2.050	
	Type:	350	ohm
	Separation (lg):	45	mm
	Attachment:	Hot cure	



A detailed list of all the proving equipment used is always clearly stated.

Photograph showing the machine and load string (Fig. 3)



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How do you Determine What Your Alignment is?

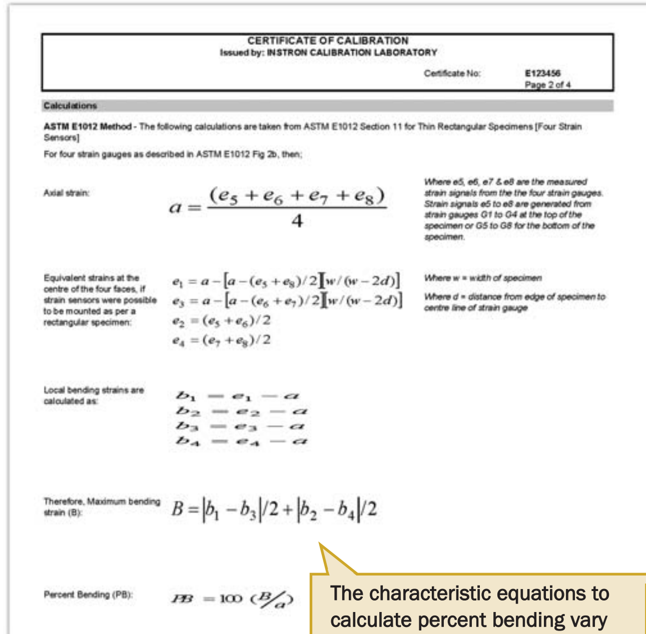
Specimen bending is the key parameter in determining alignment. You can:

- Use a strain gauged alignment cell for verification of machine and load string alignment, or
- Use a strain gauged typical test piece

Then you need to carry out a series of tests followed by some detailed calculations. ASTM has produced ASTM E 1012, which outlines the requirements and calculations. This standard is frequently quoted as an acceptable method for checking and quantifying materials testing machine alignment.

It Sounds Complicated - Is this a Service that Instron® can Offer?

Yes! You will be pleased to know that Instron Extra™ offers an alignment measuring service. We provide verification following the guidelines and calculations detailed in ASTM E 1012 and we issue a certificate. These certificates have been used as objective evidence by many of our customers to external assessment organizations, such as NADCAP, that their machines have been recently checked for alignment.



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Calculations

ASTM E1012 Method - The following calculations are taken from ASTM E1012 Section 11 for Thin Rectangular Specimens [Four Strain Sensors]

For four strain gauges as described in ASTM E1012 Fig 2b, then;

Axial strain:

$$a = \frac{(e_5 + e_6 + e_7 + e_8)}{4}$$

Where e5, e6, e7 & e8 are the measured strain signals from the the four strain gauges. Strain signals e5 to e8 are generated from strain gauges G1 to G4 at the top of the specimen or G5 to G8 for the bottom of the specimen.

Equivalent strains at the centre of the four faces, if strain sensors were possible to be mounted as per a rectangular specimen:

$$e_1 = a - [a - (e_5 + e_8)/2][w/(w - 2d)]$$
$$e_3 = a - [a - (e_6 + e_7)/2][w/(w - 2d)]$$
$$e_2 = (e_5 + e_6)/2$$
$$e_4 = (e_7 + e_8)/2$$

Where w = width of specimen

Where d = distance from edge of specimen to centre line of strain gauge

Local bending strains are calculated as:

$$b_1 = e_1 - a$$
$$b_2 = e_2 - a$$
$$b_3 = e_3 - a$$
$$b_4 = e_4 - a$$

Therefore, Maximum bending strain (B):

$$B = |b_1 - b_3|/2 + |b_2 - b_4|/2$$

Percent Bending (PB):

$$PB = 100\ (B/a)$$

The characteristic equations to calculate percent bending vary depending on specimen geometry and number of strain gauges used.

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