"Science Stays True Here"
Biological and Chemical Research, 11-22 | Science Signpost Publishing

# Differences of Latest Versions of ISO 6892-1 and ASTM E8 Tensile Testing Standards

Haldun DİZDAR, Bülent AYDEMİR and Cemal VATAN
*TÜBİTAK National Metrology Institute (TÜBİTAK UME), 41470, Gebze-Kocaeli, Turkey*
*E-Mail: haldun.dizdar@tubitak.gov.tr, bulent.aydemir@tubitak.gov.tr, cemal.vatan@tubitak.gov.tr*

**Abstract:** This paper contains some information for differences of latest versions of metallic materials tensile testing standards ISO 6892-1:2016 and ASTM E8:2016. In this context, it is aimed to increase the awareness by presenting current differences between two international standards to those who use tension testing of metallic materials in their work areas.

**Key words:** ISO 6892-1, ASTM E8, tensile testing, metallic materials, international standards

## 1. Introduction

International standards mean that consumers can have confidence that their products are safe, reliable and of good quality. Manufacturers of metals, including producers of raw material or finished metal products, need to pass compliance international standards before shipping their product. Tensile testing is imperative for ensuring a safe, high quality material. Both international standards (International Standards Organization - ISO 6892-1:2016 "Metallic materials - Tensile testing, Part 1: Method of test at room temperature" and American Society for Testing and Materials - ASTM E8:2016 "Standard Test Methods for Tension Testing of Metallic Materials") cover tension testing of metallic materials in any form at room temperature and the methods of determination of yield strength, yield point elongation, tensile strength, elongation, and reduction of area. In this paper, it is aimed to increase the awareness by presenting current differences between ISO 6892-1:2016 and ASTM E8:2016 international standards to those who use tension testing in their work areas [1-4].

## 2. Differences between Standards

### 2.1. Difference in Definition of Room Temperature Range at Which Tensile Test is to be carried out

This part of ISO 6892-1:2016 standard specifies method for tensile testing of metallic materials and defines mechanical properties which can be determined at room temperature. The test shall be carried out at

---

**Corresponding author:** Dr. Haldun DİZDAR, TÜBİTAK National Metrology Institute (TÜBİTAK UME), 41470, Gebze-Kocaeli, Turkey. E-mail: haldun.dizdar@tubitak.gov.tr.

room temperature between 10 °C and 35 °C, however, corresponding to ASTM E8:2016 standard; room temperature shall be considered to be 10 °C and 38 °C unless otherwise specified.

## 2.2. Difference in Definition of Device and Apparatus

ISO 6892-1:2016 standard specifies limited knowledge about device and apparatus used in tensile testing of metallic materials while ASTM E8: 2016 standard gives detailed information particularly gripping apparatus because various types of gripping devices may be used to transmit the measured force applied by testing machine to test specimens. ASTM E8: 2016 standard specifies grips for wedge, grips for threaded and shouldered specimens and brittle materials, grips for sheet materials, and grips for wire, in order to ensure axial tensile stress within gauge length, the axis of the test specimen should coincide with the center line of the heads of testing machine. Any departure from this requirement may introduce bending stresses. A schematic diagram of a gripping device for threaded-end specimens is shown in Figure 1.

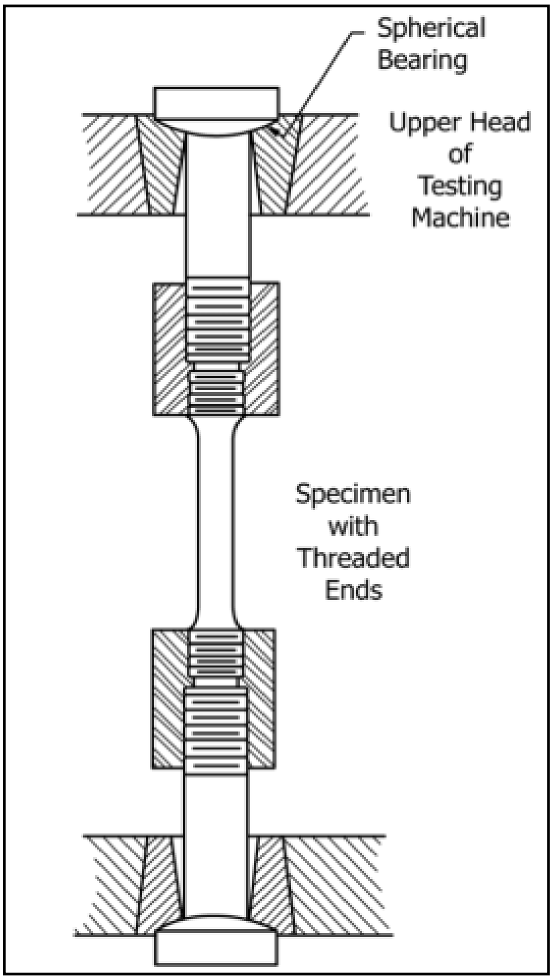


**Fig. 1** Gripping apparatus for threaded-end specimens concerning to ASTM E8: 2016 standard

## 2.3. Differences in Test Specimen Dimensions

ISO 6892-1:2016 standard declares that general information about test specimen corresponding to shape and dimensions of test specimens, machine and un-machined test specimens, types of specimens also preparation of test specimens. However ASTM E8: 2016 standard gives deep knowledge about test specimens and their dimensions. These can be express as "plate type specimens, sheet type specimens, round specimens, specimens for sheet, strip, flat wire, plate, specimens for wire, rod, bar, specimens for rectangular bar, specimens for pipe and tube, specimens for forgings, specimens for castings, specimen for malleable iron, specimen for die castings, specimen for powder metallurgy materials" respectively.

### 2.3.1. Differences of test specimen

In this paper, a rectangular plate type test specimen dimensional differences is given as an example between standards. There are also differences in dimensions of other types of tensile test specimens so details can be viewed from both ISO 6892-1:2016 and ASTM E8:2016 standards. Rectangular tension test specimen in ISO 6892-1:2016 standard is shown in Figure 2. This test specimen to be used for thin products: sheets, strips, and flats between 0.1 mm and 3.0 mm thick. Also dimensional values of specimen are given in Table 1 below.

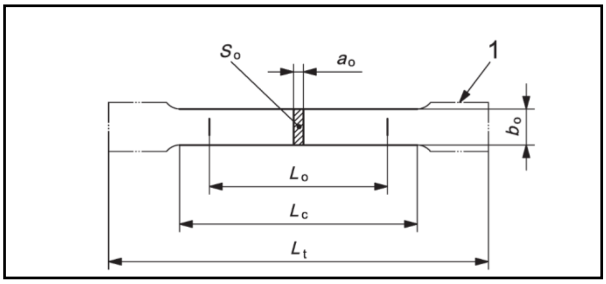


**Fig. 2** Rectangular tension test specimen in ISO 6892-1:2016

**Table 1** Plate type specimen for ISO 6892-1:2016

| Dimension of Test Specimen | (mm) |
|---|---|
| $L_0$ – Gauge length | 80.0 |
| $b_0$ – Width | 20.0 ± 1.0 |
| $L_C$ – Length of reduced parallel section, minimum | 90.0 |
| $L_C$ – Length of reduced parallel section, recommended | 120.0 |

ASTM E8:2016 standard specifies standard plate-type test specimen is shown in Figure 3. This specimen is used for testing metallic materials in the form of plate, shapes, and flat material having a nominal thickness of 5 mm or over. Additionally, dimensional values of plate type specimen for ASTM E8:2016 are given in Table 2. below.

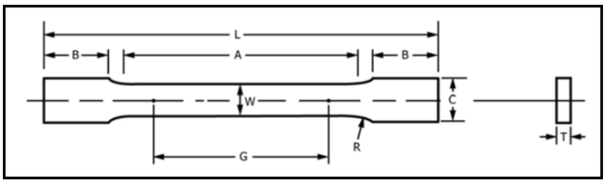


**Fig. 3** Rectangular tension test specimen in ASTM E8:2016

**Table 2** Plate type specimen for ASTM E8

| Dimension of Test Specimen | (mm) |
|---|---|
| G – Gauge length | 200.0 ± 0.2 |
| W – Width | 40.0 ± 2.0 |
| T – Thickness, minimum | 5.0 |
| R – Radius of fillet, minimum | 25.0 |
| L – Overall length, minimum | 450.0 |
| A – Length of reduced parallel section, minimum | 225.0 |
| B – Length of grip section, minimum | 75.0 |
| C – Width of grip section, approximate | 50.0 |

## 2.4. Differences in Test rates

Both standards have various methods defined for test rates. Inside these methods there is speed limitations required for use in determining yield strength, yield point elongation, tensile strength, elongation, and reduction of area, they should be stated in the product specifications. In all cases, the speed of testing shall be such that the forces (stress) and strains used in obtaining the test results are accurately indicated.

### 2.4.1. Stress rate

ASTM E8:2016 standard specifies "Control Method A - Rate of Stressing Method for Determining Yield Properties" in this method, the testing machine shall be operated such that the rate of stress application in the linear elastic region is between (1.15 and 11.5) MPa/s. However, ISO 6892-1:2016 standard specifies testing rate based on stress rate (method B). It says typical materials having a modulus of elasticity smaller than 150000 MPa include magnesium, aluminum alloys, brass, and titanium stress rate is between (2 and 20) MPa/s. Typical materials with a modulus of elasticity greater than 150000 MPa include wrought iron, steel, tungsten, and nickel-based alloys stress rate is between (6 and 60) MPa/s. All these data are given in Table 3 below:

**Table 3** Stress rate for ASTM E8 and ISO 6892-1

| Standard | Modulus of Elasticity of the Material (MPa) | Stress Rate (MPa/s) | |
|---|---|---|---|
| | | minimum | maximum |
| ASTM E8 | -.- | 1.15 | 11.5 |
| ISO 6892-1 | < 150000 | 2 | 20 |
| | ≥ 150000 | 6 | 60 |

### 2.4.2. Strain rate

ASTM E8:2016 standard declares that “Control Method B - Rate of Straining Control Method for Determining Yield Properties”— In this method, the testing machine shall be operated in closed-loop control using the extensometer signal. The rate of straining shall be set and maintained at (0.0156 ± 0.006) mm/mm/min. Whereas, ISO 6892-1:2016 standard specifies closed loop strain control, method A1, is strain rate control based on feedback of data obtained from instrument's extensometer. Application for this method is given by tolerances of required four step speed standard. Standard speed steps are schematically shown in Figure 4.

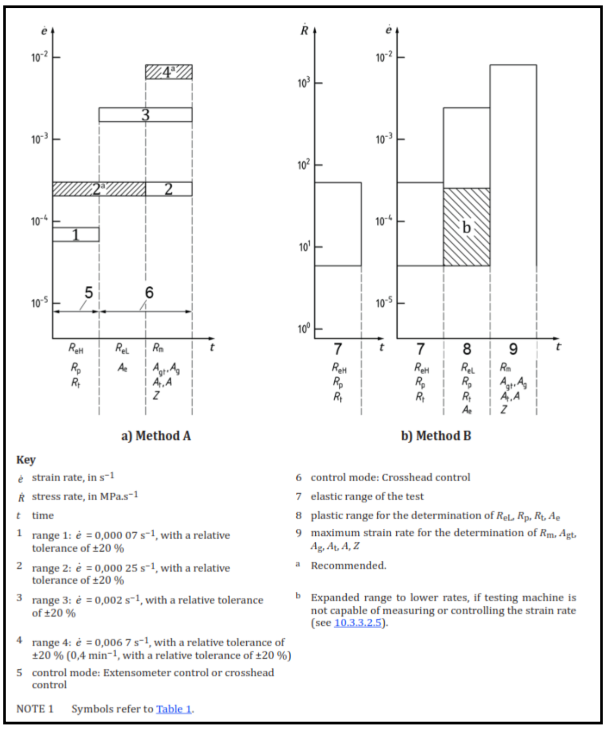


**Fig. 4** Illustration of strain rates to be used during tensile test according to ISO 6892-1:2016 standard

Symbols and designations written in Figure 4 are as follow:

Z percentage reduction of area, (%); A percentage elongation after fracture, (%); $A_g$ percentage plastic extension at maximum force, (%); $A_t$ percentage total extension at fracture, (%); $A_e$ percentage yield point extension, (%); $A_{gt}$ percentage total extension at maximum force, (%); $R_m$ tensile strength, (MPa); $R_p$ proof strength, plastic extension (MPa); $R_{eH}$ upper yield strength (MPa); $R_{eL}$ lower yield strength (MPa).

ISO 6892-1:2016 says, strain rate for determination of upper yield strength, $R_{eH}$ , or proof strength properties, $R_p$ and $R_t$; during determination of these material properties strain rate, $e_{Le}$, shall be in one of two following specified ranges.

Range 1: $e_{Le}$ = 0.00007 $s^{-1}$, with a relative tolerance of ±20 %.

Range 2: $e_{Le}$ = 0.00025 $s^{-1}$, with a relative tolerance of ±20 % (recommended, unless otherwise specified).

Strain rate for determination of the lower yield strength, $R_{Le}$, and percentage yield point extension, $A_e$, following the detection of upper yield strength, estimated strain rate over parallel length, $e_{Lc}$, shall be maintained in one of following two specified ranges until discontinuous yielding has ended.

Range 2: $e_{Lc}$ = 0.00025 $s^{-1}$, with a relative tolerance of ±20 % .

Range 3: $e_{Lc}$ = 0.002 $s^{-1}$, with a relative tolerance of ±20 %.

Strain rate for the determination of the tensile strength, $R_m$, percentage elongation after fracture, A, percentage total extension at the maximum force, $A_m$, percentage plastic extension at maximum force, $A_g$, and percentage reduction area, Z

After determination of the required yield/proof strength properties, the estimated strain rate over the parallel length, $e_{Lc}$ shall be changed to one of the following specified ranges.

Range 2: $e_{Lc}$ = 0.00025 $s^{-1}$, with a relative tolerance of ±20 %.

Range 3: $e_{Lc}$ = 0.002 $s^{-1}$,with a relative tolerance of ±20 %.

Range 4: $e_{Lc}$ = 0.0067 $s^{-1}$, with a relative tolerance of ±20 % (0.4 $min^{-1}$ with a relative tolerance of ±20 %).

If the purpose of the tensile test is only to determine the tensile strength, then an estimated strain rate over parallel length of the test piece according to range 3 or 4 may be applied throughout the entire test.

ASTM E8:2016 standard specifies that "Control Method C - Crosshead Speed Control Method for Determining Yield Properties"- The testing machine shall be set to a crosshead speed equal to (0.0156 ± 0.003) mm/mm/min of the original reduced parallel section. However, ISO 6892-1:2016 Method A2, open loop strain control, involves the control of the estimated strain rate over the parallel length, ($e_{Lc}$), which is achieved by using the crosshead separation speed ($V_c$) calculated by multiplying the required strain rate by the parallel length.

$$\upsilon_c = L_c \cdot \dot{e_{Lc}} \quad (1)$$

## 2.5. Differences in Calibration and Accuracy Condition of Device and Equipments to be used in Tensile Testing of Metallic Materials

Device and equipments to be used in tensile testing of metallic materials should have traceability to National Measurement Standards. On the other hand, they should fulfill calibration and accuracy requirements mentioned below:

### 2.5.1. Force-proving instrument

This part of ISO 6892-1:2016 standard specifies, force-measuring system of material testing machine shall be in accordance with ISO 7500-1:2015 “Metallic materials-Calibration and verification of static uniaxial testing machines Part 1: Tension/compression testing machines-Calibration and verification of the force-measuring system” standard [7]; Class 1, in relevant range, but corresponding to ASTM E8:2016 standard force-measuring system of material testing machine shall be in accordance with ASTM E4:2016 “Standard Practices for Force Verification of Testing Machines” in relevant range [8]. In additionally, ASTM E8:2016 standard says, where verification of testing machine speed is required, Practices ASTM E2658:2015 “Standard Practices for Verification of Speed for Material Testing Machines” shall be used unless otherwise specified [9].

### 2.5.2. Extensometer system

Extensometer system shall be in accordance with ISO 9513:2012 “Metallic materials-Calibration of extensometer systems used in uniaxial testing” standard [10]; Class 0.5 in the relevant range for ISO 6892-1:2016 standard. The strain shall be measured on opposite sides of the test piece. The use of a large extensometer gauge length (e.g. ≥50 mm) is recommended. Whereas, ASTM E8:2016 standard declares that extensometer system shall be in accordance with ASTM E83:2016 “Standard Practice for Verification and Classification of Extensometer Systems” standard; Class B2 or better Class extensometer shall be used in tensile testing processing of metallic materials [11].

#### 2.5.3. Resolution of tensile testing system

ISO 6892-1:2016 standard consider that resolution of tensile testing system shall be sufficient for obtaining at least 50 different discrete measured values in the evaluation range, also the measuring device shall be able to guarantee an accuracy of the measured data of better than ±0.5 % of the measured value, while ASTM E8:2016 says, relative measurement error should be kept at or below 1 %, where possible. Ideally, this 1 % error should include not only the resolution of the measuring device but also the variability commonly referred to as repeatability and reproducibility. In additionally ASTM E8:2016 declared that micrometers and other devices used in measurement of specimen dimensions should be selected, maintained and used in such a manner as to comply with the appendixes of Test Methods E8 on measurement. Traceability to national standards should be established for these devices, and reasonable effort should be employed to prevent errors greater than 1 % from being generated as a result of measurement error, resolution, and rounding practice.

### 2.6. Uncertainty

ISO 6892-1:2016 is included “Estimation of the uncertainty of measurement” as Annex K. This Annex gives guidance on how to estimate the uncertainty of the values determined in accordance with this part of ISO 6892-1:2016. The standard uncertainty, *u*, of the value of a parameter can be estimated in two ways [1, 5, 12].

#### 2.6.1. Type A Uncertainty

It is evaluated by repeated measurement:

$$u = \frac{s}{\sqrt{n}} \tag{2}$$

where, *s* is the standard deviation of the measurements; *n* is the number of observations being averaged to report the result of the measurement under normal circumstances.

#### 2.6.2. Type B Uncertainty

It is evaluated from some other source, e.g. calibration certificates or tolerances. The true value is equally likely to occur anywhere within the defined interval so the distribution is described as rectangular or uniform. Here the standard uncertainty is given by formula (3):

$$u = \frac{a}{\sqrt{3}} \tag{3}$$

where, *a*: is half the width of the interval in which the quantity is assumed to lie.

Often the estimation of a quantity, $y$, involves the measurement of other quantities. The estimation of the uncertainty in y shall take account of the contributions of the uncertainties in all these measurements. It is thus known as a combined uncertainty. If the estimation simply involves the addition or subtraction of a series of measurements,

$$u(x) = \sqrt{(u(x_1)^2 + u(x_2)^2 + \ldots + u(x_n)^2)} \quad (4)$$

where, $u(x)$ is the uncertainty in the parameter $x_1$ etc.

### 2.6.3. Parameters effect on the uncertainty of test results

Uncertainty of results determined from a tensile test contains components due to the equipment used. Various test results have differing uncertainty contributions depending on the way they are determined in Table 4 below.

**Table 4** Uncertainty contributions due to measuring devices

| Parameter | $R_{eH}$ | $R_{eL}$ | $R_m$ | $R_p$ | A | Z |
|---|---|---|---|---|---|---|
| Force | X | X | X | X | - | - |
| Extension | - | - | - | X | X | - |
| Gauge Length | - | - | - | X | X | - |
| $S_o$ | X | X | X | X | - | X |
| $S_u$ | - | - | - | - | - | X |

X Relevant

- Not relevant

Symbols and designations written in Table 4 are given below:

$S_o$ original cross-sectional area of parallel length (mm$^2$); $S_u$ minimum cross-sectional area after fracture (mm$^2$)

According to test results written in Table 4, some of the test results can be determined with a lower uncertainty than others, e.g. upper yield strength, $R_{eH}$, is only dependent on the uncertainties of measurement of force and cross-sectional area, while proof strength, $R_p$, is dependent on force, extension, gauge length, cross-sectional area, and other parameters. For reduction of area, Z, the measurement uncertainties of cross-sectional area both before and after fracture need to be considered. On the other hand, ASTM E8:2016 standard does not include any information in the context of tensile testing uncertainty calculation and budgeting.

## 2.7. Differences in Test Reports

Test report to be prepared at the end of tensile test according to both standards shall contain the following information:

- Reference to the standard used, i.e. ASTM E8:2016 or ISO 6892-1:2016.
- Material and sample identification.
- Specimen type.

While ASTM E8:2016 standard requires that following specifications be specified in test report:

Yield strength and method used to determine yield strength.

- Yield point elongation.
- Tensile strength.
- Elongation.
- Uniform elongation, if required.
- Reduction of area, if required.

ISO 6892-1:2016 standard specifies that it should be included in test report, in particular with some of the parameters specified below.

- Testing control mode and testing rate or testing rate range if different from the recommended methods and values given in standard.
- Test results should be rounded (according to ISO 80000-1) to the following precisions or better, if not otherwise specified in product standards: strength values, in megapascals, to the nearest whole number;
- Percentage yield point extension values, A, to the nearest 0.1 %.
- All other percentage extension and elongation values to the nearest 0.5 %.
- Percentage reduction of area, Z, to the nearest 1 %.

In addition, if requested by the user, ASTM E8:2016 standard specifies that it should be included in test report with following characteristics:

- Specimen test section dimension(s).
- Equation used to calculate cross-sectional area of rectangular specimens taken from large-diameter tubular products.
- Speed and method used to determine speed of testing.

## 3. Accreditation Criteria for Laboratories Performing Tensile Test

In ASTM E8:2016 standard there is an appendix which is name of title “X3”-“Suggested Accreditation Criteria for Laboratories Performing Tensile Tests” Inside appendix X3, there are specific features that an assessor may check to assess a laboratory’s technical competence, if the laboratory is performing tests in accordance with Test Methods ASTM E8:2016.

In this context, main criteria are:

- Preparation,
- Test equipment,
- Procedures,
- Retention,
- Environment,
- Controls,

On the other hand, such a chapter is not included in ISO 6892-1:2016 standard.

## 4. Conclusion

In this study, significant differences have been summarized between ISO 6892-1:2016 and ASTM E8:2016 standard. It can be specified difference in definition of room temperature range at which tensile test is to be carried out; difference in definition of device and apparatus used in test, differences in test specimens dimensions. Both standards have various methods defined for test rates. Inside these methods, there is speed limitations required for use in determining yield strength, yield point elongation, tensile strength, elongation, and reduction of area, they should be stated in product specifications. In this respect, all aspects of test rates differences have been examined concerning to ISO 6892-1:2016 and ASTM E8:2016 standard. Device and equipments to be used in tensile testing of metallic materials should have traceability to National Measurement Standards; therefore, differences in requirements of both of ISO 6892-1:2016 and ASTM E8:2016 standards have been expressed in detail. Furthermore, uncertainty of tensile test measurement results has been mentioned. Similarities and differences between two standards have been revealed in the scope of tension test report to be prepared by laboratories the tensile test. In additionally, suggested accreditation criteria for laboratories performing tensile test have been emphasized.

Finally, it has been aimed to help for understanding tensile test of metallic materials topic particularly laboratories that perform tension test concerning to ISO 6892-1:2016 and ASTM E8:2016 standard.

# References

[1]. ISO 6892-1, Metallic materials - Tensile testing - Part 1: “Method of test at room temperature”, 2016.

[2]. ASTM E8, Standard Test Methods for Tension Testing of Metallic Materials, 2016.

[3]. B. Aydemir, “The Changes in ISO 6892-1:2016 Metallic Materials Tensile Testing Standard” 3rd Iron and Steel Symposium (UDCS’17), 3-5 April 2017, Karabuk – TURKEY.

[4]. B. Aydemir, H. Taşcan, C. Camyurdu, “Çekme deneyinde farklı uzama ölçme yöntemlerinin etkilerinin incelenmesi”, 2015, Metal Dünyası, Sayı 266, S.44-50, İstanbul.

[5]. B. Aydemir, “Malzeme Deneylerinde (Çekme deneyi) Ölçüm Belirsizliğinin Hesaplanması Eğitim Dokümanı” – G2KV-110, Nisan 2015, TÜBİTAK UME.

[6]. Updates to metals standards 2015, www.instron.com.

[7]. ISO 7500-1, Metallic materials -Calibration and verification of static uniaxial testing machines Part 1: Tension/compression testing machines-Calibration and verification of the force-measuring system, 2015.

[8]. ASTM E4, Standard Practices for Force Verification of Testing Machines, 2016.

[9]. ASTM E2658, Standard Practices for Verification of Speed for Material Testing Machines, 2015.

[10]. ISO 9513, Metallic materials - Calibration of extensometer systems used in uniaxial testing, 2012.

[11]. ASTM E83, Standard Practice for Verification and Classification of Extensometer Systems, 2016.

[12]. B. Aydemir, “Malzeme Deneylerinde (Çekme deneyi) Ölçüm Belirsizliğinin Hesaplanması Eğitim Dokümanı” - G2KV-110, Nisan 2015, TÜBİTAK UME.