XIX IMEKO World Congress
Fundamental and Applied Metrology
September 6–11, 2009, Lisbon, Portugal

FLAT SURFACE TEMPERATURE PROBE INFLUENCE ON TEMPERATURE MEASUREMENT

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Abstract – This paper deals with the influence of the flat surface temperature probe measuring temperature. Different measurement approaches for measuring surface temperature are possible. For the purpose of safety testing of household appliances surface temperature measurements are very important. General requirements are presented in European standards, [1], which support requirements in European Low Voltage Directive 2006/95/EC. Paper introduces comparison of temperature measurement between attached thermocouple on the measured surface and measurement with flat surface temperature probe. As a heat generator an oven and a temperature artefact are used. Probes and thermocouples are applied to the surface in horizontal and vertical position, using also different force for application of probes. Reference temperature was measured by J-type fine-wire (0.2 mm) thermocouple. Two probes were homemade according to requirements in [2], but one with fine-wire (0.2 mm) thermocouple and one with 0.5 mm of thermocouple wire diameter. The third compared probe was a commercial one not in accordance with the standard requirement for dimensions. Results showed that only probe with fine-wire thermocouple can be used for the measurement of surface temperature. It's deviation from the reference thermocouple attached to the surface was the lowest. The other probes also influenced the unit measured so that the temperature dropped.

Keywords: surface temperature, testing, contact probe

1. INTRODUCTION

This article addresses the problem of measuring the surface temperature. For this type of measurement, there are different approaches. Basically, the measurements can be performed on the non-contact way with pyrometer or with thermal imager, or on the contact way. The article discussed the last. This article is limited to the requirement to measure surface temperatures when testing household and similar electrical appliances according to European standard EN 60335-1. The content of the standard states the international acceptable level of protection against the hazards and basic safety requirements according to Low Voltage Directive 2006/95/EC. This article refers to the testing of heating in accordance with the requirements of section 11. Appliances and their surroundings in normal use should not be heated above the prescribed limit. Compliance is checked by determining the temperature rise under specific conditions. Particular requirements for the heating test of grills, toasters, ovens and similar portable household appliances and use of probes for measuring the surface temperature are listed in [2]. The inducement for the analysis described in the article, was a requirement of this standard for temperature probe, while the standard footnote additionally states that also any other instrument, which gives the same result, as prescribed probe can be used. This article, therefore, deals with the measurements comparison of surface temperature measured by a thermocouple fixed to the surface of the test apparatus, the commercial contact probe LMK488 and laboratory produced contact probes marked as LMK1418 and LMK 1432.

2. PROBES FOR MEASURING SURFACE TEMPERATURES

In testing the surface temperature is measured by attaching thermocouple firmly to the observation area. Since this kind of measurement with appropriate mounting of thermocouple is time consuming, the EN 60335-2-9 standard and some other standards allow the measurement of surface temperatures with contact probes as presented in Fig. 1.

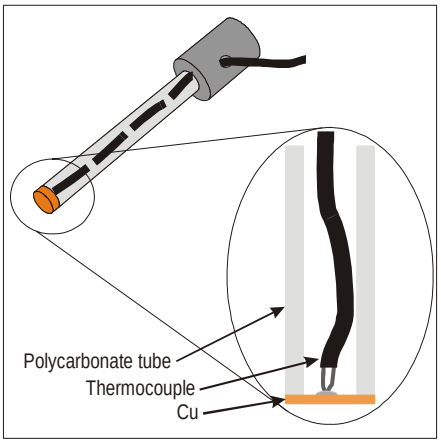

Fig. 1. Probe for measuring flat surface temperatures

ISBN 978-963-88410-0-1

Requirements for this probe are listed in [2]. The probe shall consist of polycarbonate tube with internal diameter of 3 mm, outer diameter 5 mm and with the adapter for dynamometer. On the tube copper plate with diameter of 5 mm and with thickness of 0.5 mm is attached. On this plate Type K thermocouple wire with a diameter of 0.3 mm is mounted. In a comparative measurement as a reference thermometer, glued on the surface, a J-type thermocouple, with wire diameter of 0.2 mm, marked as LMK BTC 06-01, was used. It was connected to the data acquisition system to automatically detect the temperature. The measured temperature of the thermocouple was compared with the temperature measured by contact probes shown in Fig. 2:

- Probe symbol: LMK488
  Commercial contact probe T120-2 9H with display ALMENO 2290-2 with 3 mm, contact surface diameter,
- Probe symbol: LMK1418
  Laboratory created the probe in accordance with the requirements of the standard. Deviation from the requirements is thickness of the thermocouple wire, which is 0.5 mm instead of at least 0.3 mm,
- Probe symbol: LMK1432
  Laboratory created the probe in accordance with the requirements of the standard. Thermocouple wire diameter is 0.2 mm.

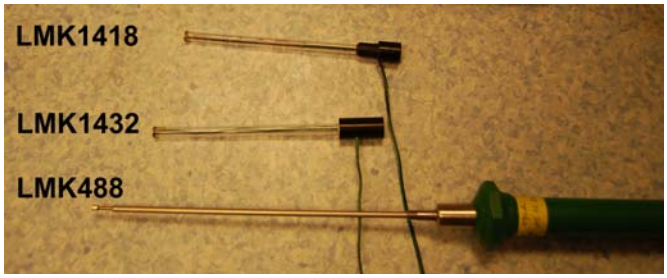

Fig. 2. Contact probes used in the comparison

2.1. Calibration of compared contact probes

Contact probe calibration was carried out in accredited calibration laboratory in the range from 0 ° C to 125 ° C. Fig. 3 shows the deviations of all three probes.

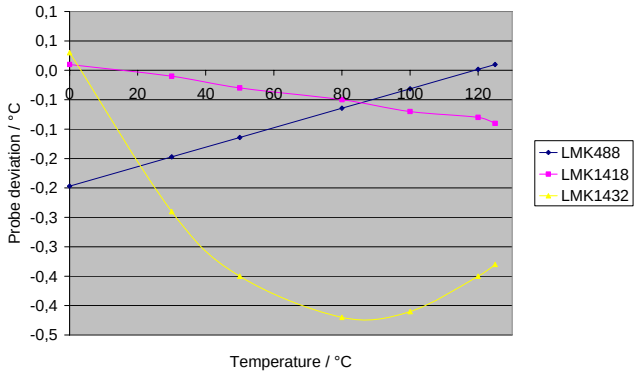

Fig. 3. Temperature deviations of probes

Probe LMK1418 with thickest wire has the smallest deviation, the maximum deviation, however has the LMK1432 probe. The expanded measurement uncertainty (k = 2) given in the calibration certificate for each probe is 0.6 ° C for LMK488, for the LMK1418 probe 0.2 ° C, for the LMK1432 probe 0.3 ° C and for the reference thermocouple 0.7 ° C .

Correction for thermocouple, which is attached to the surface, is already included in the displayed value, as well as corrections for LMK1418 probe while corrections for LMK488 and LMK143 probes are not taken into account in the recorded result, but later in the evaluation of the results.

3. COMPARISON REALIZATION

Measurement of surface temperatures, we carried out using the temperature artefact and the electric oven, which is the practical application of probes (Fig. 4).

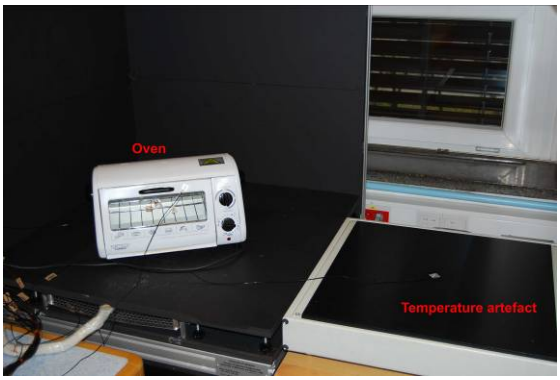

Fig. 4. Measurement on the oven and on the temperature artefact

Measurements were carried out using the contact probes in the horizontal and vertical directions in the immediate vicinity of the fixed thermocouple (Fig. 5 and Fig. 6).

Fig. 5. The position of the probe during measurement horizontally and vertically on the oven

During testing, pressure by means of a dynamometer with a force of 4 N ± 1 N and the increased pressure to force 30 N ± 1 N were applied. No significant change of the results was found out, except for the probe LMK488, which is mainly attributed due to relatively small contact area.

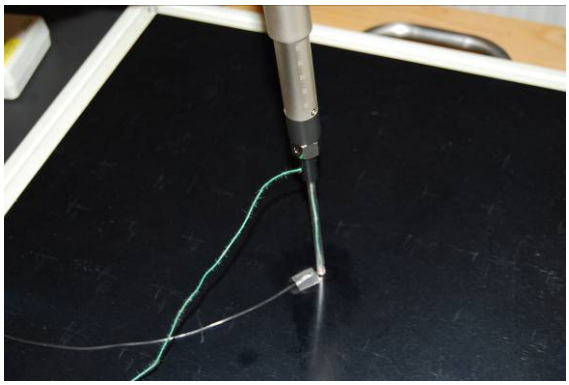

Fig. 6. The position of the probe during measurement vertically to the temperature artefact

4. SUMMARY OF MEASUREMENTS

The results of the LMK488, LMK1418 and LMK1432 probes compared to the reference thermocouple are shown in Table 1. In the first column are markings of the probes in the second column are locations of measurement. In the third column is the reference value obtained by reference thermocouples, which were attached to the surface. The fourth column presents the uncorrected measured values. The fifth column presents the corrections of the probes and the sixth column contains the corrected values. The last column of Table 1 contains the deviations from the reference value. An example of probe response when in contact with the measured surface is presented in Fig. 7.

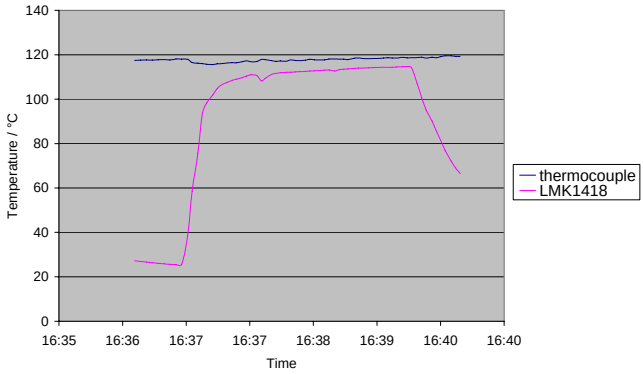

Fig. 7. Deviation of probe, LMK1418 from the reference thermocouple on the artefact at the temperature of 120 ° C

The probe LMK1418 with wire diameter of 0.5 mm influences the surface temperature of the measured item, the temperature measured by reference thermocouple drops just after application of the LMK1418 probe. Quite some time is needed that surface temperature reaches the same temperature as it vas before application of the probe.

Table 1. Gathered results of compared contact temperature probes

Probes	***On temperature artefact***	Reference value (°C)	Measured value (°C)	Correction (°C)	Corrected value (°C)	Deviation from reference (°C)
LMK488	horizontal 4 N	120,1	111,1	0,0	111,1	-9,0
LMK1418	horizontal 4 N	120,1	117,2	-0,1	117,1	-3,0
LMK1432	horizontal 4 N	120,1	119,3	-0,4	118,9	-1,2
LMK488	horizontal 30 N	120,1	117,1	0,0	117,1	-3,0
LMK1418	horizontal 30 N	120,1	117,3	-0,1	117,2	-2,9
LMK1432	horizontal 30 N	120,1	119,3	-0,4	118,9	-1,2
LMK488	vertical 4 N	120,0	112,2	0,0	112,2	-7,8
LMK1418	vertical 4 N	120,0	117,0	-0,1	116,9	-3,1
LMK1432	vertical 4 N	120,2	119,5	-0,4	119,1	-1,1
Probes	***On oven's***	Reference value (°C)	Measured value (°C)	Correction (°C)	Corrected value (°C)	Deviation from reference (°C)
LMK488	door	117,5	104,3	0,0	104,3	-13,2
LMK1418	door	118,8	114,4	-0,1	114,3	-4,5
LMK1432	door	117,8	117,9	-0,4	117,5	-0,3
LMK488	top	92,1	83,2	-0,1	83,1	-9,0
LMK1418	top	91,2	88,0	-0,1	87,9	-3,3
LMK1432	top	91,8	91,6	-0,4	91,2	-0,6
LMK488	back side	67,3	59,6	-0,1	59,5	-7,8
LMK1418	back side	66,4	64,3	0,0	64,3	-2,1
LMK1432	back side	68,5	68,6	-0,4	68,2	-0,3

In Fig. 8 are presented deviations of temperature probes applied to artefact. The impact of the use of different forces was seen only for the LMK488 probe, which has smaller contact area and, with increased force achieves a better contact.

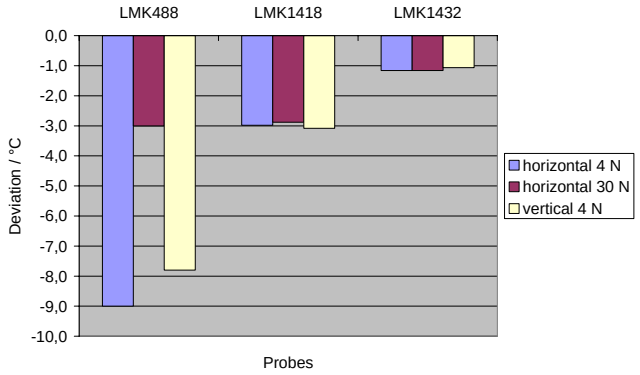

Fig. 8. Deviation of probes LMK488, LMK1418 and LMK1432 from the reference thermocouples on the artefakta at the temperature of 120 ° C

Fig. 9 presents deviations of the probes applied on the door, upper part and back side of the oven. Results show differences between various probes, but also different deviations at different temperatures because of the different locations of measurement. Temperature is not the same at all locations.

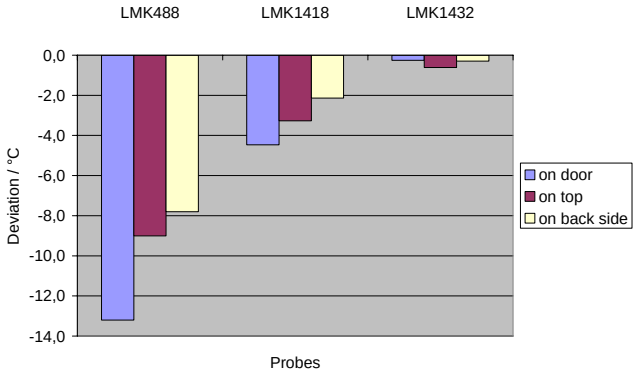

Fig. 9. Deviation of probes LMK488, LMK1418 and LMK1432 from the reference thermocouples on the oven

4. CONCLUSIONS

Presented example in this paper is oriented to specific problems of surface temperature measurement of electrical appliances during safety testing. It is evident from the results that the probe LMK488 is not suitable for measuring the surface temperatures according to referred standard requirement, because obtained values deviate significantly from the value of fixed thermocouple and the other two probes. The probe with its mass and thermal conductivity of the material also very cools down the measured surrounding. The LMK1418 with thermocouple wire diameter of 0.5 mm deviate from the value of fixed thermocouple for about 3 ° C and the impact of the heat removal can be seen. The LMK1432 probe with the thermocouple, which has a wire diameter of 0.2 mm, is only appropriate for measuring the surface temperature in testing of electrical appliances in accordance with the standards, because of small deviation from the reference thermocouple, fast response and practically no or very low heat loss is observed at probe application. This research showed, that it is very important what measurement instrument is used for measuring the surface temperature in order to avoid cooling to much the measured surface and to measure the correct value, which is very much close to reference value measured by thermocouple fixed to the surface.

REFERENCES

[1] European Committee for Electrotechnical Standardization, European standard EN 60335-1:2002, Household and similar electrical appliances – Safety – Part 1: General requirements.

[2] European Committee for Electrotechnical Standardization, European standard EN 60335-2-9/A12:2007, Household and similar electrical appliances – Safety – Part 1: Particular requirements for grills, toasters and similar portable cooking appliances.