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INACCURACY OF FOOD TEMPERATURE MEASUREMENT WITH THE BIMETALLIC COIL (DIAL) THERMOMETER

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Introduction

The food thermometer commonly used by cooks is the bimetallic coil thermometer with a range of 0 to 220ºF.

Figure 1 is a cutaway picture of the bimetallic coil thermometer, showing the bimetallic coil starting at about 1/4 inch from the tip, extending up the stem about 2 to 2/12 inches in most models. In order to accurately measure temperature of food, the thermometer must be inserted in food so that the complete coil length is in the food. Then, it registers the average temperature from the tip to the top end of the coil. Therefore, if one end is 125ºF, and the other end is 175ºF, the thermometer indicates 150ºF. (Snyder, 1996; Snyder 1999; Snyder 2001)

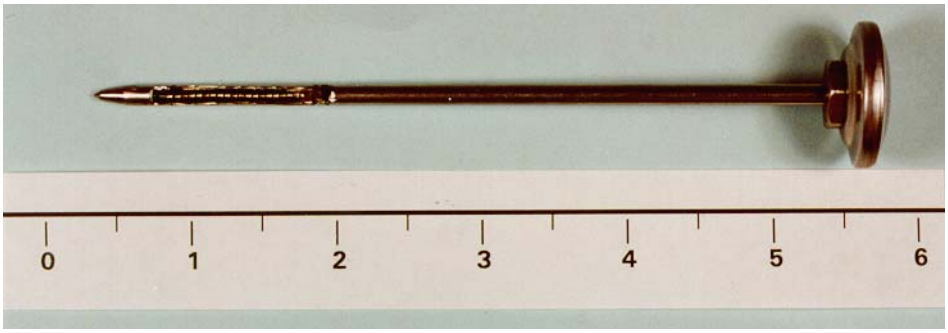

Figure 1. Cutaway of bimetallic coil thermometer

Taylor Precision Products LP puts a dimple on the stem of its thermometers to indicate that the stem and bimetallic coil must be inserted beyond the dimple so that the entire coil will be in the food in order to get an accurate measurement. However, most bimetallic coil thermometer manufacturers put no dimple on the stem, and the thermometers do not come with instructions to explain the inaccuracy of temperature measurement if only the tip is inserted into the food, and the stem is not immersed.

This design characteristic leads to an even more serious problem, that it is virtually impossible to accurately measure thin foods such as a chicken breast, a hamburger, or scrambled eggs as they cook. One must guess that the food has reached a required temperature and must take the food off of the cooking device in order to insert the thermometer from the side of the food to get the entire coil into the food and measure an average temperature. It can take a minute or more to get a reading. If the temperature of the food is found to be low, the food really has begun to cool, and it is not practical to restart the cooking process. As a result, the cook may choose to

overcook the food so that he/she does not have to use a thermometer, because it is too complicated and takes too long, or uses the thermometer incorrectly by putting just the tip into the food, perhaps 1/2 inch.

This study was conducted to measure the deviations of food temperature measurement if a cook mistakenly inserts just the tip of the bimetallic coil thermometer into a typical thin piece of food rather than insert the stem through the side of the food so that the entire coil is surrounded by food.

Methods

A Taylor 2-inch bitherm (Taylor Precision Products LP; 2311 West 22nd Street; Oakbrook, IL 60523; www.taylorusa.com) with a dimple at 1 3/4 inches up the stem and a measurement range of 0 to 220ºF was used in this experiment. It was calibrated to 120ºF in warm water in an insulated cup, using a glass precision thermometer (Miller and Weber; 1637 George Street; Ridgewood, Queens, NY 11385-5342; www.millerweber.com). The bimetallic coil thermometer was modified by soldering 30-gauge iron-constantan thermocouple junctions at the tip, 7/8 inch up the stem (the middle of the coil), and 1 3/4 inches up the stem (at the top end of the coil). In this experiment, the middle and top thermocouples were not used; only the thermocouple at the tip was measured. A calibration temperature of 120ºF was used so that errors in the bimetallic coil would be divided in half between low-temperature dial readings and high-temperature dial readings. The result was that the thermocouple reading was within 1ºF of the bimetallic coil thermometer. The thermocouple meter that was used was Tegam model 821 (Tegam, Inc.; 10 Tegam Way; Geneva, OH 44041; www.tegam.com).

Four foods were used in this experiment, as shown in Figures 2, 3, 4, and 5.

Figure 2. Meatball by Rosina. Weight 1 oz. Diameter 1 1/2 inches.
Figure 3. Hot dog by Bar S. Diameter 3/4 inch. Length 4 1/2 inches.
Figure 4. Chicken breast from Cub Foods. Grilled, fully cooked chopped and formed fillet. Thickness 1/2 inch. Diameter 4 inches.
Figure 5. Hamburger, 85% lean, from Cub Foods. Weight 0.33 lb. Diameter 4 inches. Thickness 1/2 inch.

The meatball, hot dog, and chicken breast were heated in a microwave oven. The hamburger was cooked in an electric skillet.

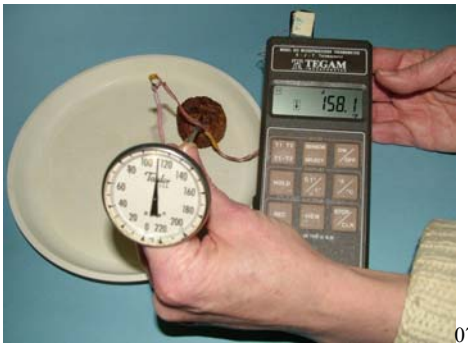

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Figure 2. Meatball

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Figure 3. Hot dog

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Figure 4. Chicken breast

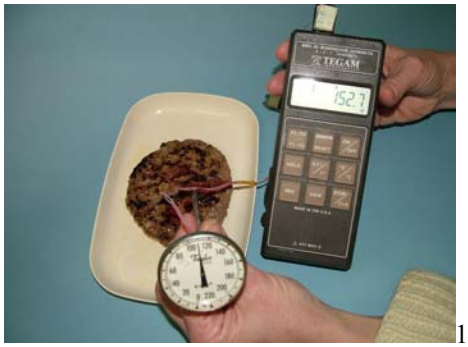

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Figure 5. Hamburger, 85% lean

Results

Table 1 shows the results of the temperature measurement. It shows, first, the temperature measured by the thermocouple at the tip. Next, it shows the temperature indicated on the bimetallic coil thermometer dial. The last column is the temperature difference between the thermocouple and dial reading.

Table 1. Temperature Measurement Results

Food Item	Thermocouple Temperature (ºF)	Bimetallic Coil Thermometer Temperature (ºF)	Difference in Temperature, ΔT (ºF)
Meatball	158.1	110	48.1
Hot dog	150.3	140	10.3
Chicken breast	133.3	96	37.3
Hamburger, 85% lean	152.7	110	42.7

Discussion

As expected, because of the design of the bimetallic coil thermometer, inserting the tip into food about 1/2 inch gave a bimetallic reading that was from 10 to 48ºF below the actual center temperature of the food, as measured by the thermocouple at the tip. The only way to use a bimetallic coil thermometer is to insert it into the food a full 3 inches to make sure that the coil is totally surrounded by food. Of course, measuring a large volume of food like this will not allow an accurate reading of a small cold spot in the food.

While the bimetallic coil thermometer with the stem immersed 3 inches into slush ice can be calibrated to ±2ºF, it will not give an accurate temperature for foods unless the entire coil is immersed in the food. Except under very unusual food conditions such as a stirred pot of soup or cup of coffee, where the entire coil can be surrounded by uniform-temperature food, this thermometer will not give an accurate reading of food cold or hot spots and will not meet FDA Food Code (2001) requirements for an accurate food temperature measurement at ±2ºF.

Conclusions

When used by people who are not trained to use the thermometer correctly and assume that the tip is the sensing point, the bimetallic coil thermometer gives a very inaccurate, lower measurement of the center temperature of hot food than the actual center temperature. This can lead to significant overcooking of food in order to reach a "safe" temperature reading as indicated by the thermometer.

Since there are no instructions in the Food Code as to correct use of this thermometer for measuring food temperatures during cooking or cooling, a cook will have no idea as to whether a

food has been adequately pasteurized or not, or to what extent pathogens are growing in the food. The bimetallic coil thermometer should not be used by cooks to measure food temperature. A tip-sensitive thermistor or thermocouple probe should be used. These thermometers are three to four times faster and provide a tip-sensitive reading.

Summary

This study has shown that inserting just the tip of a bimetallic coil thermometer into food does not give the required ±2ºF accurate measurement of food temperature. Since the bimetallic coil thermometer will give a low reading of hot food, this will lead to unnecessarily overcooked, dried out food. This thermometer does not give accurate measurements of food temperature, and all regulatory agencies should prohibit its use by cooks to measure food temperature.

References:

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