The Best of the Best: Portable Tools for the Food Sanitarian

By Robert W. Powitz, Ph.D., MPH
It was about 15 years ago while working for the Commonwealth of Pennsylvania as defendant’s sanitarian that I noticed something amiss when the plaintiff’s expert tried to measure the internal temperature of a thin, cooked meat patty with a bi-metal thermometer. That single incident prompted me to take a critical look at the use and misuse of field instrumentation I was using at the time and those that were available to regulatory practitioners.

Together with Jim Balsamo, Director of Environmental Health and Safety at Tulane University, we started on a quest to seriously evaluate the field instruments we were using during our kitchen inspections and food plant audits. It didn’t take us long to recognize that some of our field instruments were better than others—and where improvements to both the instruments and their instructions would benefit field utility and marketability. We started to acquire the latest portable field instruments available and use them (as well as abuse them) during our consulting field work.

To find the ones that are the most rugged, accurate and affordable portable instruments with the greatest utility, we patterned our evaluations similar to Consumer Reports. Without bias, we wrote about the good, the bad and the ugly in a regularly appearing column in the Journal of Environmental Health. And we did so without incurring the wrath of those we panned. We also began conducting numerous hands-on workshops around the country in which we offered our experiences with these instruments to regulatory and industry sanitarians; where we also got their feedback, opinions and ideas. Because of our evaluations and tutorials, several manufacturers incorporated changes into their instruments’ design.

To assuage doubts about our impartiality, please be assured that the field equipment presented in this column are the ones we regularly use on the
job. Over the years, we developed an evaluation form to present our findings in a factual and unbiased logical manner. We buy most of our instruments through manufacturers, dealers and distributors; those that are donated to us for evaluation are done so with no strings attached. If any instrument does not pass muster, so be it. Our motto remains: There is no special dispensation for largesse. It is what it is.

**Criteria and Selection Methods**

A bit of background information about our evaluation methodology is in order. We are in the forensic business and often travel considerable distances to serve our clients. The instruments we use in the field are often subjected to environmental extremes by being carried in a car, in the belly of a plane, or by an express mail carrier to the job site. Additionally, we use these instruments in a variety of settings from food manufacturing plants to large institutional kitchens, to fast food and fine restaurants, caterers, grocery stores, food warehouses and temporary food operations, just to name a few. When we are at the work site, there is little opportunity to retrieve a specialized instrument from our office to help us measure any problematic environmental parameters we may encounter. Therefore, our instrument kit is designed to help us measure or evaluate most, if not all food safety-related criteria listed in the Food Code.

We want to emphasize that the instruments we reviewed and listed in the “Best of the Best” are designed for field use and are most suitable for the itinerant sanitary or quality control technologist. Food safety instruments used exclusively in-house; that is, not subjected to the environmental extremes of transporting them from place to place may have completely different operating and use criteria. We view portable field instrumentation as a basic extension of our senses. It helps us to qualify and quantify that which we observe, smell or touch. As such, we use 10 key points in
evaluation. The instruments we take into the field must meet the following criteria:

**Portability.** Every instrument must be fully portable; preferably small in size, lightweight, nonreactive, rugged and safe to use. Because of transportation logistics, the smaller and lighter, the better. All instruments designed for field use must be rugged to withstand hard and repeated use, minor impacts and not be subjected to interference or damage by adverse environmental conditions such as temperature extremes during transportation. We realize that some instruments are more sensitive than others to changing environmental conditions. However, for obvious reasons, we prefer those that do not require extraordinary protective measures to maintain them in optimal operating condition.

**Cleanability.** Every instrument should have food contact surfaces that are either disposable, easily cleaned or decontaminated between uses, or easily protected from contamination while in use. We feel that all of our field equipment must be as clean or cleaner than any utensil or food processing equipment we inspect.

**Ease of Operation.** All field instruments should be relatively simple and easy to operate with one hand. In the case of most sanitarians, they generally hold a notebook or clipboard, pen and flashlight in their other hand. For repetitive measurements, one-handed operation is virtually a must.
**Readability.** All portable instruments should be easy to read, even under poor lighting conditions. We prefer the display either backlit or of high contrast. In addition, given a choice, we favor instruments that provide for direct reading. If this is not available, we favor those that require only minimal interpretation of results.

**Price.** Cost is a factor. Preferably, field instruments should be relatively inexpensive. However, there are exceptions to this rule. We found that accuracy, ruggedness and utility often come at a price. The least expensive is not always the best value.

**Power.** If powered, we favor those instruments that run on “standard” batteries: C, D, AA, AAA and 9-volt. These batteries are inexpensive, easy to replace and are readily available at most convenience stores.

**Expendables.** Expendable materials used with any of our instruments should be nonproprietary. This is often a tough one to achieve, particularly with those field instruments that use a more complex sensor system. However, where expendable materials are proprietary, they should be field-stable, easily obtainable and relatively inexpensive.

**Field Accuracy.** Portable instruments should be easy to calibrate or validate in the field to ensure accuracy. Any instrument that is transported can be subjected to changes. Simple field calibration/ validation is essential to ensure accuracy.

**Non-toxic.** If any part of the instrument comes in contact with food or food contact surfaces, it should be non-toxic (preferably NSF listed) and conform to ANSI/NSF Standard 51: Food Equipment Materials.
**Conformance to standards.** Whenever possible, we chose instruments that are manufactured in accordance to an established standard. In addition, whenever possible or practical, we chose those instruments that are referenced to standard protocols. We also look for portable field instruments that are versatile and can be used to take accurate and numerous measurements in a myriad of different settings.

Needless to say since we started these evaluations, we have become a trifle more discriminating and far more objective in our selection of tools that accompany us to our job sites. Most recently, when we conduct the evaluation of any instrument, we use an evaluation form in which we list the aforementioned attributes and grade each one from A to F, based upon our perception of the unit’s performance in the field. Although the grading system is more subjective than we like, it is nonetheless generally quite accurate and complete. Only those instruments with an overall average of a “B” grade or better in all our expectations will make it to the “Best of the Best.” The few exceptions to this rule are due to an instrument’s uniqueness and/or usefulness. Because we use our instruments in support of our forensic work, we often have to defend our choices in court. We are proud to say that our recommendations have held up under rather intense scrutiny in both testimony and deposition. As an aside, we were probably the first to introduce the infrared thermometer as a food safety screening tool into court records.

Our “Best of the Best” are presented in four categories; the first three have specific criteria listed in the Food Code. Because it is so critical to food safety and basic to all inspections and audits, we list temperature-measuring instruments in their own category: thermometry. And, since form follows function, the next category lists the other instruments we use to measure some parameter, which is part of the definition of potentially hazardous
foods (PHFs). Next in the listing, is a category we affectionately call Food Code Necessities, which contains those field instruments for which the Food Code has a specific value. Finally, the “Other Essentials” category contains tools that help us measure some of the operating conditions detailed in consensus standards, serve as teaching aides, or helps us evaluate the very subjective query, “How clean is clean?”

We have purposely not included prices, since these will vary depending upon the vendor. We’ve learned that everything is negotiable. However, since we presented this topic two years ago, some newer equipment has been added to our food safety tool box. The basic cost for the field instruments listed here is roughly $10,000, give or take a dollar or two.

**Thermometry**

Thermometry is the backbone of local regulatory food safety. In conducting Food Code compliance inspections, we rely on every type of thermometer; there is no single device that can fast and accurate measurements under all conditions. We find ourselves using the many different temperature measuring devices available to us. And the more we use them, the more proficient we become in their use and interpretation. Consequently, with proficiency comes preference in our choice of instruments. I find myself using at least five different temperature measuring devices to evaluate the potential for temperature abuse in even the most limited-menu retail food establishments; more if I am evaluating a food processor, dairy plant or if I am conducting a complex HACCP audit. The following represents the range of thermometric devices used in the field. The thermometers are listed in no particular order of preference; each plays a separate yet necessary part in a thorough food safety evaluation.

**Bi-metal Thermometer.** The 0°F to 200°F range, 1-inch dial; 5-inch
stem bi-metal dial thermometer remains the handiest and probably our most versatile tool. We use it for almost all noncritical temperature measurements, particularly in those areas where we can place a thermometer, go about our business and retrieve it later when it has had time to equilibrate such as in refrigeration equipment and ambient temperatures of processing and storage areas. We find that placing several of these in containers of warm water throughout a refrigeration unit, we can easily see the “sweet spot.” I carry at least a dozen bi-metal thermometers with me to all inspections, audits and evaluations—and I conveniently leave one or two behind where they do the most good.

Because the bi-metal thermometer so handy and versatile, we have refined our criteria to meet the following:

• The dial should be easy to read, even under poor lighting conditions that may be found in older walk-in refrigeration units and dry storage rooms. We look for crisply painted numerals on the dials and a bright contrasting color such as red on the indicator hand.

• Given a preference, I appreciate a lens that offers some magnification. This helps to use the thermometer at arm’s length, under less than optimal lighting conditions.

• The distance from stem tip to the dimple that indicates proper immersion for accuracy, should not exceed 2 inches; the shorter, the better. In fact, the best bi-metal thermometer has its’ dimple about 1 inch from the tip of the stem.

• For safety, it must be NSF listed and conform to ANSI/NSF Standard 51: Food Equipment Materials.
• For ruggedness and non-toxic properties, the dial case and bezel, as well as the stem, should be made of 304 stainless steel or equivalent. Plastic or other less rugged materials can easily break under normal use and become a physical food contaminant.

• For utility, we found that the carrying case should hold the thermometer securely anywhere along the stem. This allows for its placement on refrigerator racks or other wire surfaces. Therefore, the traditional plastic case with a metal clip is much preferred to the newer molded all-plastic cases, which simply do not hold the thermometer securely other than when it is fully depressed in the case.

The pocket bi-metal thermometer that still best meets these criteria without stretching the budget is the Pocket Test Thermometer, Part Number B1098M82C-5.0 manufactured by the MILJOCO Corp.

**Thermocouple Thermometer.** For critical temperature measurements, the needle-probe thermocouple thermometer is preferred thermometric device, and for good reason. The thermocouple thermometer is convenient, fast responding, rugged and accurate. While all thermocouple thermometers demonstrate about the same performance, there are distinct differences between brands. Over the past 15 years, we evaluated more than a dozen of the more common units found in the field and used by local sanitarians. The ones we favor have a few characteristics in common:

• If we only need or use a needle probe, we appreciate having the K-type connector integral with the unit. This ensures a tight waterproof connection that does not serve as a catch area for food and debris. It also avoids any sharp edges from the male plug to cord connection. More than once I’ve skinned a finger on such an appurtenance.
• We really appreciate having our thermocouple thermometer powered by the less expensive and more convenient AA size battery rather than the 9-volt battery. The AA batter compartment with a waterproof screw-type closure makes it easier to service and ensures a sealed unit if it becomes wet.

• Any thermocouple thermometer used in the field should be NSF listed to ensure compliance with ANSI/NSF Standard 51.

• Because the thermocouple thermometer is the most frequent used during an audit or inspection; the display should be easy to read. Backlighting is an exceptionally nice feature.

• The thermometer case housing the electronics should be rugged and cleanable. We tend to shy away from units that have a rubber sleeve because it tends to trap for food particles and debris between the sleeve and the unit. We also found similar problems with units where the probe is stored within a sleeve that is part of the housing.

As with many instruments, accuracy and utility come at a price. The best thermocouple thermometers are not the least expensive. For these reasons, we are quite partial to the Cooper Atkins AccuTuff model numbers 33032 and 34032. Both units come with a needle probe.

When conducting HACCP audits, the thermocouple thermometer has to accept a variety of probes. Almost any unit that meets our original criteria will be suitable; although we still favor those powered by AA batteries such as the Atkins VersaTuff Series 386 or 396. In addition, the Comark C28 K type is also nicely designed and versatile. The case is comfortable in the hand and is easily cleanable. In addition, it features a clock, timer and hold
function. I would be remiss if I did not mention the newest units that combine a K-type probe with a PDA device. These are far more functional for in-plant work than in the field; the displays are cluttered and not well suited for multitasking when performing an inspection or audit.

I use about nine different K-type probes for most comprehensive HACCP audits. The probes are purchased from several different vendors based on my preferences of their geometry and convenience of use. I also found it quite handy to have a coiled retractable extension cable in my HACCP kit to access those hard-to-reach places.

Manufacturers of thermocouple units will tell you that mixing and matching the thermometer and probes from various sources may not be a good idea. So, to overcome any problems with accuracy, we recommend the use of a Dwyer Instrument Model CA10 digital thermocouple calibrator to validate the base unit and each probe. Because the CA10 calibrator is just slightly larger than most thermocouple units, it is ideal to take along for field validation, or use as a thermocouple base unit.

**Thermister Thermometer.** The pen-type thermister thermometer is the ideal instrument when we need a waterproof electronic minimum/maximum-registering thermometer; particularly when we have only one free hand and no chance of seeing the LCD readout during the measurement. Because of their diminutive size, the LCD readout is not always easy to see; even under the best lighting conditions. However, the min/max feature and “hold” button allows you to take a temperature and read the display when a more suitable opportunity presents itself. There are so many manufacturers and distributors of these little units; it’s more a matter of color and price and whether we prefer the more traditional pen-type unit or the “lollipop” with a perpendicular readout. The only
requirement I believe important is that the control buttons are easy to operate by touch (trust me on this one). I also favor those thermister thermometers where the button battery is easily replaceable. Although there are some units that claim to have field calibration capability, for most application, a simple validation is sufficient.

Of all the thermister thermometers I have amassed over the years, my personal favorite is the DPP400W Waterproof Pen Style manufactured by Cooper Atkins. I find that it is the easiest to use through “feel” because of its raised buttons. The pen-style thermister has the additional advantage of its probe shield serving as a holder for the thermometer in the same manner as the carrying sleeve of the bi-metal thermometer. The pen-style thermister is also quite portable and takes up little room in a shirt pocket.

**Infrared Thermometer.** Back in 1996, we were the first to introduce the affordable infrared (IR) thermometer to our industry. Since then, we have had considerable practice in its use and found a myriad of new applications for it in our environmental health practice, particularly when the IR thermometer is used in conjunction with other measuring equipment. We participated on the original UL 2333 standard committee that set out to codify performance and standardize the instructional manual language for the infrared thermometers that are primarily used in the food industry.

For most of the early years, our preferences were rather catholic; it seemed like every month a new and improved unit would be introduced to our profession. However, over the past few years, the IRs have become refined in size and operation. Today’s IR units have a preset emissivity at 0.97 and with the addition of light and laser spots, the aspect ratios are no longer left to guess work. However, it doesn’t matter how sophisticated these units have become or how ideal they are designed for food safety application, they...
are still a rapid screening tool that can only measure surface temperatures.

The Fluke Co., which manufactures the Raytek infrared thermometers, designed three relatively inexpensive units specifically for use in our industry. These three actually complement one another and collectively they can be easily used anywhere within a facility. The NSF-listed FoodPro Series which consists of two, hand washable models. They are known as the FoodPro and the FoodPro Plus. Both units have a 2.5:1 aspect ratio with a target illuminating system, and red/green, go/no-go lights that immediately shows if the temperature is within HACCP guidelines. Needless to say, this is a great feature; the colored light is easier to see than any readout. In addition, the FoodPro Plus has a probe and timer that makes it ideal for production line food safety assessment. At first, I found it a bit awkward to handle, but with use one learns of its advantage in certain situations. The third of the series is the MiniTemp FS. This is a single point, laser sighted, backlit, trigger operated, lightweight IR unit that fits nicely in a holster and is one of the most ergonomically-friendly and useful field tools in our arsenal of thermometric devices.

Omega markets a unique IR thermometer for food safety application. Its model OSXL450 has a unique laser circle dot sight and a 6:1 field of view that makes it an ideal tool for taking surface temperature measurements at a distance from the target. The Omega unit is CE listed.

**Single-Use Paper Thermometer.** In evaluating a warewasher, our first choice is a thermocouple thermometer with an Atkins 50415 dishwasher probe. However, for routine inspections and day-to-day quality assurance we found the paper thermometer to be convenient and quite accurate. We rely almost exclusively on the self-adhering Thermolabel Dishwasher Labels, manufactured by the Paper Thermometer Co. Our reasons for this selection
are the following: First, the self-adhering label works on any clean porcelain or metal surface. Secondly, in so doing, the Thermolabel measures the surface temperature on a heat-sink, which implies a dwell time. Thirdly, the label is accurate to within 1% of the calibrated temperature, and finally, the label is removable and can be repasted on the inspection report as a permanent record.

**Other PHF Tools**

The Food Code also defines potentially hazardous foods in terms of water activity (AW) and pH, and the interaction between the two under certain conditions. Therefore, any comprehensive food safety evaluation of retail food establishments and food processors must include the monitoring of water activity and pH.

**Water Activity.** There are a few very good portable water activity monitors offered in the marketplace. Most of them are similar to the pen-type hygrometer and not really easy to operate. About seven years ago, Decagon Devices, Inc. introduced the easy-to-use and compact Pawkit. The Pawkit is a small, lightweight field kit for measuring water activity in foods. We find it most useful in separating foods requiring refrigeration from those that do not. We also use the Pawkit for measuring ambient relative humidity, if conditions call for it.

Measuring water activity with the Pawkit is relatively simple, particularly with their newly designed unit. Just open the bottom of the instrument, insert your sample, and press a button. In 5 minutes, the water activity measurement will appear on the display screen along with the temperature. Calibration is also easy to check and adjust whenever necessary. The complete kit contains everything needed for field work including the instrument, sample cups, and verification standards.
Measuring pH. I can honestly say that I probably spent more time, effort and money on finding reliable pH field monitoring equipment and techniques than any other instrumentation. In spite of numerous attempts and numerous models, we still have had no luck or mixed results with pH pens when used in the field. The pH pens do well back in the lab, but whether it is the jarring of moving them or modest temperature extremes from transporting them to the jobsite; it seems that we always had to rely on some other method for pH screening to validate our readings. Even with the setbacks, we are not giving up hope of finding a unit that will withstand the rigors of field work.

So, for the past several years, we left the pH pens in the shop and settled on two easy, albeit crude methods of measuring pH in the field. While they are not as accurate, both systems are excellent for screening purposes. If we need more accurate readings, we take a sample back to the lab and use the electronic device. The two methods are detailed below:

1. The first method is a bit more traditional in the world of pH measurement. It consists of a small Nalgene plastic dropper bottle filled with buffered deionized water and a package of Watman Type CF, 0–14 pH indicator papers. The sample is mixed with the buffered water in a clean glass container (shot glasses are ideal for this purpose) and the indicator paper inserted into the liquid. Surprisingly, even colored liquids do not mask the endpoint of the Watman indicators. Both the dropper bottle and indicator papers are available through most scientific supply retailers.

2. For measuring sushi rice or any other lower moisture foods, we use a technique borrowed from agronomy and horticulture: the LaMotte soil pH kit. The kit contains a Duplex indicator liquid that yields absolutely the most
striking endpoint with the least effort. Simply place a small sample of food in the white porcelain well and drop the indicator liquid on the food until saturated. The excess liquid will flow to the lower well from which a color comparison can be made. Although the color comparator chart only registers in whole numbers, the endpoint provides a good estimate of the foods’ pH. The test is simple, convenient and inexpensive.

**Food Code Necessities**

**Light Meter.** The Food Code specifies illumination in food production and storage facilities. These specifications are often overlooked. We know that you can’t clean what you can’t see and adequate lighting is absolutely essential for good sanitation and safety. To measure light, we are still partial to the Type 217 GE light meter in spite of the advances and elegance of the larger digital units. The 217 GE light meter is the ideal portable instrument: about half the size of a digital light meter, quite rugged, versatile, lightweight, and best of all, it uses the light it measures as its energy source. No batteries. Its only drawback is that it cannot measure illumination below 10-foot candles, but this is of little consequence since the Food Code lighting requirements start at the 10-foot candle level. This little unit is available through most scientific catalogs for under $100.

**Sanitizer Indicator Papers.** The reaction on most chlorine indicating papers is a change in the intensity of blue color. We use Code 4250-BJ, acid-free LaMotte Chlorine Test Papers, whose endpoint color is probably the easiest to interpret.

Quaternary ammonium chloride sanitizers however are measured with pH. The pHydron QT-40 test papers, catalog number 230004, manufactured by Micro Essential Laboratory, relies on color change. The comparator with each roll pack is given in parts per million. The manufacturer has a wide
variety of sanitizer test kits available for applications beyond that of the Food Code including disinfectant concentrations used in general housekeeping.

**Ventilation.** In an effort to characterize ventilation, particularly direction and flow, we rely on the Flowchecker, offered by Lab Safety Supply. This is an amorphous silicon dioxide powder in a small plastic squeeze bottle. The puff of this very finely divided powder is somewhat persistent in air and will indicate directionality. We find it particularly useful in assessing canopy hoods and general kitchen ventilation. For something a bit less expensive, try a zinc stearate powder in a small empty nasal spray bottle. It works in the same manner and is safe around food.

To complement this low-tech method to see direction and flow, we also take along the inexpensive and compact Dwyer Instrument 460 Air Meter. This kit basically consists of a float type air meter, a supply and return probe, a piece of hose connection, cleaning materials and a wallet case. For about $30, it is probably the lowest cost instrument for measuring velocity or static-pressure available, and is surprisingly quite accurate.

**Water.** One of the most overlooked requirements in the Food Code is “quantity and availability” of water. This is of particular concern in the operation of warewashing equipment and ice makers. It is also of concern in some older establishments with old plumbing or in retail food outlets located on less-than-adequate public supplies. There is an inexpensive piece of equipment to evaluate both pressure and flow at the same time. It is called the Comprehensive Water Gauge and is available through Professional Equipment. It consists of two gauges: PSI and GPM; a flow reduction outlet and brass control valve. The gauge attaches to any standard hose bib or utility sink faucet. Although it is a bit hefty at about a pound in
weight and bulky because of the gauges and valve, it’s used only use once at each establishment inspected. On the plus side, it is completely assembled from standard plumbing parts which make the gauge quite rugged and easily transportable.

**Other Essentials**

The “Other Essentials” listed below are part of our food sanitarian field kits and accompany us to each job. They are the necessary tools required to conduct a comprehensive and professional inspection, audit or evaluation.

**ATP.** The most exciting technology to emerge on the food safety scene is the adenosine triphosphate (ATP) rapid hygiene test monitoring system. We can now determine “how clean is clean” with objective accuracy, from crop harvest to clean rooms. It has become a standard instrument in most, if not all, field investigations. Its application is only limited by one’s imagination.

I obtained my first ATP monitoring system seven years ago and I have never been without one since. I find it particularly useful in validating HACCP programs and in evaluating the cleanliness of food contact surfaces and monitoring cleaning methodologies. A word of caution needs to be interjected at this point. The ATP test is not a substitute for routine bacteri

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