The Importance of Temperature Monitoring in your Lab

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Control Company

January 2016

Agenda

Temperature Measurement – Critical to Laboratory Processes

Topics:

- Effects in laboratory – temperature measurement importance
- Drive to accurate and reliable temperature measurement results
- Temperature measurement technologies
- Consistency and Reliability – calibrated and accredited measurement
- Measurement to Monitoring
  - Put down the pen - let technology record
  - Wireless technology and remote notification

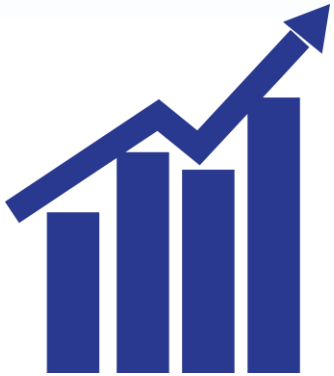
Listen to the replay HERE

What Does Temperature effect in the lab?

Temperature is one of the most universally impactful parameters in the laboratory. Among other things, it can significantly influence:

Test results

Shelf life & Efficacy



Effectiveness & stability

Accuracy & Precision

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How important is temperature monitoring?

Food Safety Lessons Learned in 2015

The high priority of food safety constantly drives the Food Service industry to search for new tools to reduce the incidence of food-borne illness. The percentage of food that is recalled due to pathogens may be very small, but the volume of the food supply is so large that even when a rare incident of contamination does strike, it can be devastating — to companies as well as to consumers.

In spite of diligent food safety efforts, more than 48 million people suffer from food-borne illness each year, according to the Centers for Disease Control. Robert Scharff, a professor of Consumer Science at Ohio State University, estimates the total annual health-related costs of food-borne illness to be $77 billion. Food safety is therefore an area of great interest and is becoming big business.

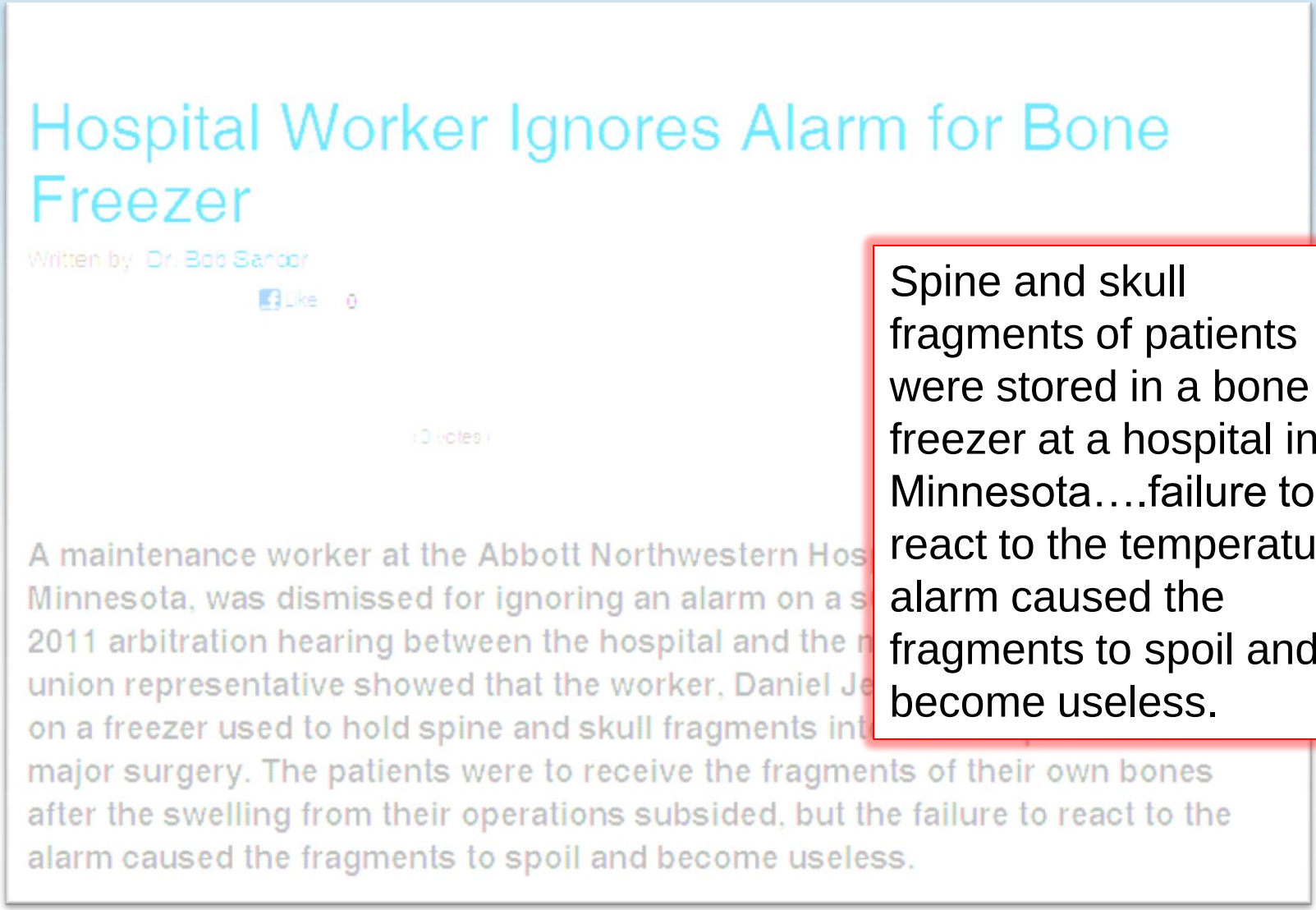
place in 2011, when Cargill voluntarily recalled 36 million pounds of turkey due to *Salmonella* contaminated the turkey aren't entirely known, but new measures by have
ditional pathogen reduction steps throughc
that the company's food safety program is g
contamination, and the use of high pressur

The CDC estimates that more than 48 million people in the US suffer from food-borne illness each year resulting in annual health-related costs of $77 billion

…eliminating cross contamination and monitoring the food's temperature play vital roles in pathogen reduction

Source - https://www.equities.com/news/food-safety-lessons-learned-in-2015

How important is temperature monitoring?



Hospital Worker Ignores Alarm for Bone Freezer

Written by: Dr. Bob Sandor

Like 0

A maintenance worker at the Abbott Northwestern Hos
Minnesota, was dismissed for ignoring an alarm on a s
2011 arbitration hearing between the hospital and the
union representative showed that the worker, Daniel Je
on a freezer used to hold spine and skull fragments int
major surgery. The patients were to receive the fragments of their own bones after the swelling from their operations subsided, but the failure to react to the alarm caused the fragments to spoil and become useless.

Spine and skull fragments of patients were stored in a bone freezer at a hospital in Minnesota….failure to react to the temperature alarm caused the fragments to spoil and become useless.

How important is temperature monitoring?

Refrigerator Failure Renders Vaccine Ineffective

An October news article described how a vaccine supply in a Massachusetts town was rendered ineffective due to a refrigerator failure over an August weekend. The Massachusetts event is one of many vaccine refrigeration failures reported over time. As noted by the CDC

The CDC notes that the improper storage and handling of vaccines can cost small clinics thousands of dollars each year.

Weekends are particularly vulnerable for vaccine loss due personnel may not be available to monitor the units, an conducted twice daily. For this reason vaccine refrigeration units should be equipped to monitor their internal temperatures and provide warning in case of temperature excursions.

Source - http://www.tovatech.com/blog/25582/lab-refrigerator/refrigerator-failure-renders-vaccines-ineffective

Common agencies/guidelines driving use of calibrated instruments

USP

FDA

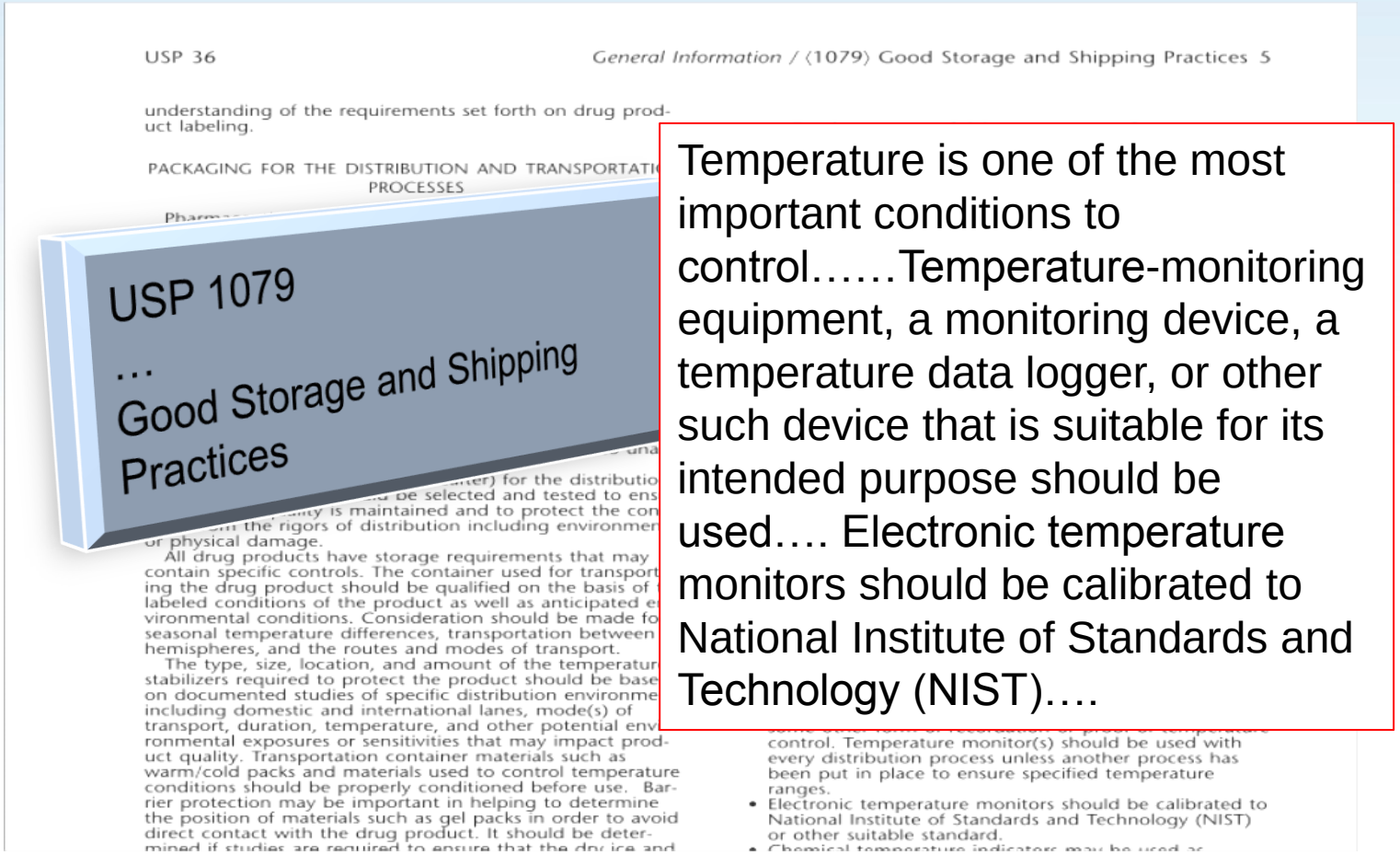
ISO

Some other accreditation/certification programs

- CLIA – Clinical Laboratory Improvement Amendment
- JCAHO – Joint Commission on Accreditation of Healthcare Organizations
- CAP – College of American Pathologists
- …….

The Drive - USP Requirement For Calibrated Temperature Measurement Instrument

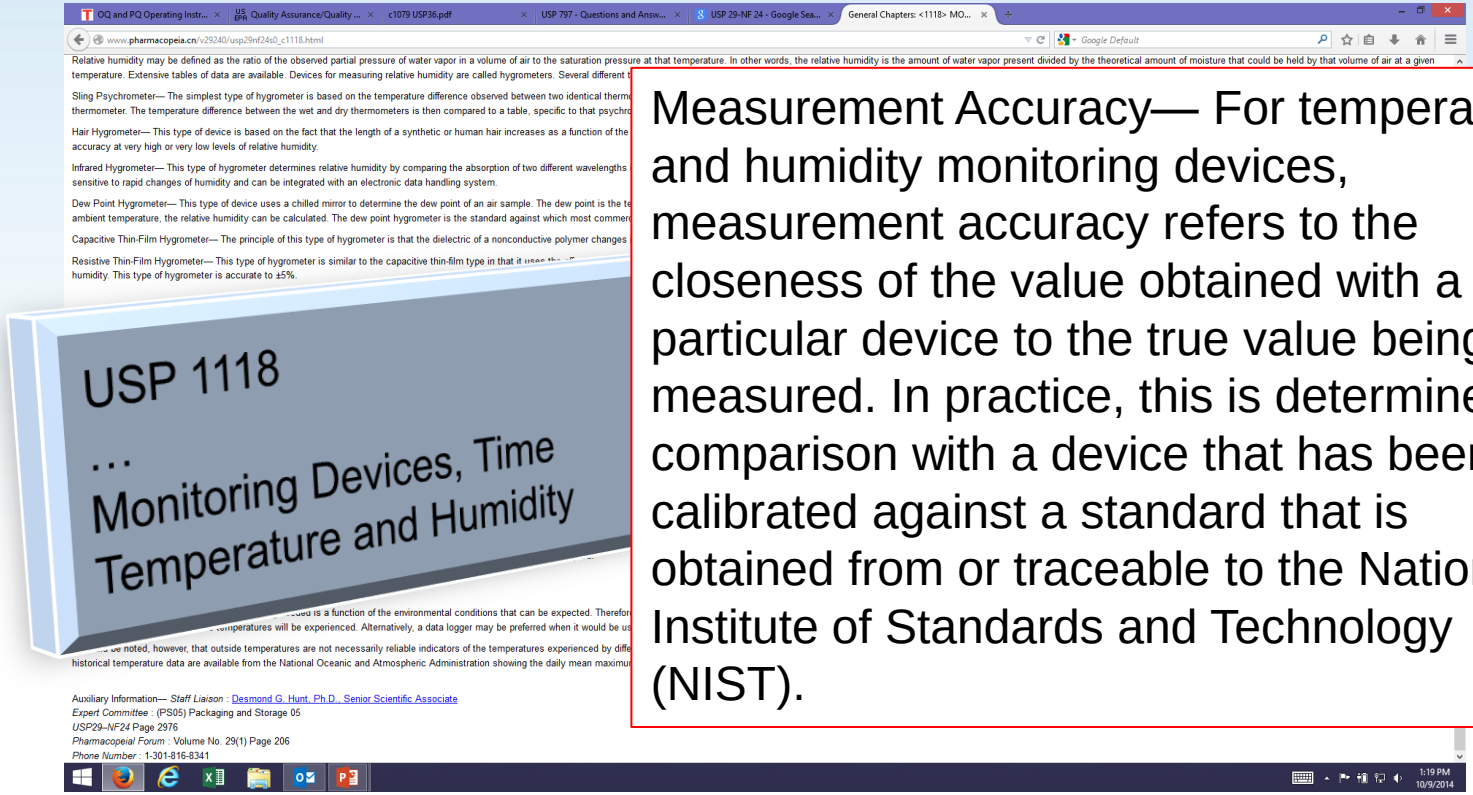
USP 1079 – Critical to drug manufacturers, shipping companies and warehouses storing Pharmacopeial products



Temperature is one of the most important conditions to control……Temperature-monitoring equipment, a monitoring device, a temperature data logger, or other such device that is suitable for its intended purpose should be used…. Electronic temperature monitors should be calibrated to National Institute of Standards and Technology (NIST)….

The Drive - USP Requirement For Calibrated Temperature Measurement Instrument

USP 1118 – Important to all companies audited by the FDA



Measurement Accuracy— For temperature and humidity monitoring devices, measurement accuracy refers to the closeness of the value obtained with a particular device to the true value being measured. In practice, this is determined by comparison with a device that has been calibrated against a standard that is obtained from or traceable to the National Institute of Standards and Technology (NIST).

The Drive - FDA Requirement For Calibrated Temperature Measurement Instrument

Industries following FDA requirements include pharmaceutical, dietary supplements, nutraceutical and food companies

All FDA requirements can be found in the Code of Federal Regulations (CFR)

Details the requirements for establishing and maintaining calibration standards, records and controls for measurement and test equipment

Specific areas that address calibration requirements include 21CFR:

- **Part 58–** Good laboratory practice for nonclinical lab studies
- **Part 110–** Current good manufacturing practice (cGMP) in manufacturing, packing or holding human food equipment and utensil maintenance
- **Part 211–** cGMP for finished pharmaceuticals
- **Part 606–** cGMP for blood and components
- **Part 820–** cGMP that governs methods used in – and the facilities and controls used for – design, manufacture, packaging, labeling, storage, installation and services of all finished devices intended for human use

The Drive - FDA Warning Letter – Non-Compliance for Calibrated Thermometers

Warning Letter

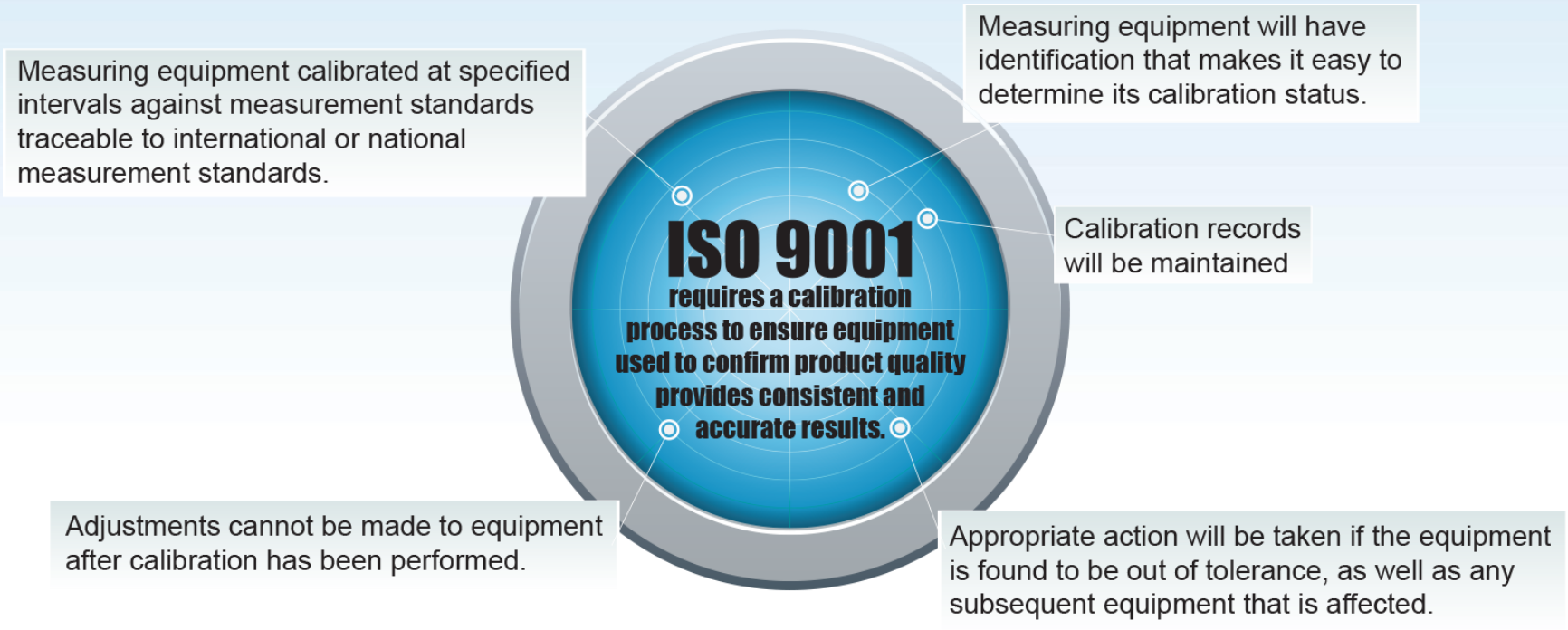
[redacted]

August 18, 2008

- Failure to ensure that calibration procedures include specific directions and limits for accuracy and precision, as required by 21 CFR 820.72(b).
- For example, the temperature gauges used for monitoring the package sealing equipment are not calibrated using limits for accuracy. Specifically, during calibration, temperatures exhibited on sealing apparatuses range from less that [redacted] to greater than [redacted] however, there is no indication as to which temperature ranges are acceptable to ensure monitoring gauges are operating with calibration standards.
- We have reviewed your response and have concluded that it is inadequate because it only states that validation of the heat sealer used on sterilized packaging is conducted [redacted] and provides a correction completion date of June 2008. Your firm should submit documentation as evidence of the implementation of the correction and the corrective action that demonstrates that the temperature gauges used for monitoring package sealing equipment were calibrated using limits for the accuracy.

The Drive - ISO 9001 – Clause 7.6 Control of monitoring and measuring equipment

Manufacturing, service and distribution companies accredited to ISO 9001:2008



Standardization for same requirements between ISO 9001:2008 and 13485:2003

Sources - http://www.isorequirements.com/iso_9001_7.6_control_of_monitoring_and_measuring_equipment.html
International Organization for Standardization, *ISO 9001:2008 – Quality management system – Requirements*
International Organization for Standardization, *ISO 13485:2003 – Quality management systems – Requirements for regulatory purposes*

The Drive— Accreditation and Certification

Accreditation and ISO certification: do they explain differences in quality management in European hospitals?

Abstract

BACKGROUND: Hospital accreditation and International Standardization Organization (ISO) certification offer alternative mechanisms for improving safety and quality, or as a mark of achievement. There is little published evidence on their relative merits.

OBJECTIVE: To identify systematic differences in quality management between hospitals that were accredited, or certificated, or neither. Research design

ANALYSIS: of compliance with measures of quality in 89 hospitals in six countries, as assessed by external auditors using a standardized tool, as part of the EC-funded

METHODS: of Assessing Response to Quality Improvement Strategies project.

MAIN OUTCOME MEASURES: Compliance scores in six dimensions of each hospital-grouped according to the achievement of accreditation, certification or neither.

RESULTS: Of the 89 hospitals selected for external audit, 34 were accredited (without ISO certification), 10 were certificated under ISO 9001 (without accreditation) and 27 had neither accreditation nor certification. Overall percentage scores for 229 criteria of quality and safety were 66.9, 60.0 and 51.2, respectively. Analysis confirmed statistically significant differences comparing mean scores by the type of external assessment (accreditation, certification or neither); however, it did not substantially differentiate between accreditation and certification only. Some of these associations with external assessments were confounded by the country in which the sample hospitals were located.

CONCLUSIONS: It appears that **quality and safety structures and procedures are more evident in hospitals with either the type of external assessment** and suggest that some differences exist between accredited versus certified hospitals. Interpretation of these results, however, is limited by the sample size and confounded by variations in the application of accreditation and certification within and between countries.

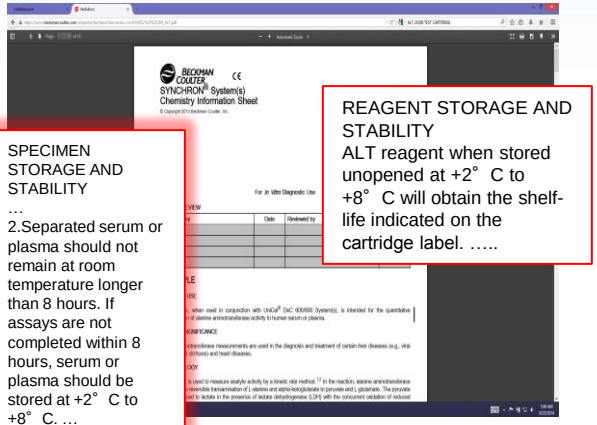
Int J Qual Health Care. 2010 Dec;22(6):445-51. doi: 10.1093/intqhc/mzq054. Epub 2010 Oct 8.
http://www.ncbi.nlm.nih.gov/pubmed/20935006

Who Needs Calibrated Products?

Any work environment held to standards should use individually calibrated measurement instruments – for all process variables

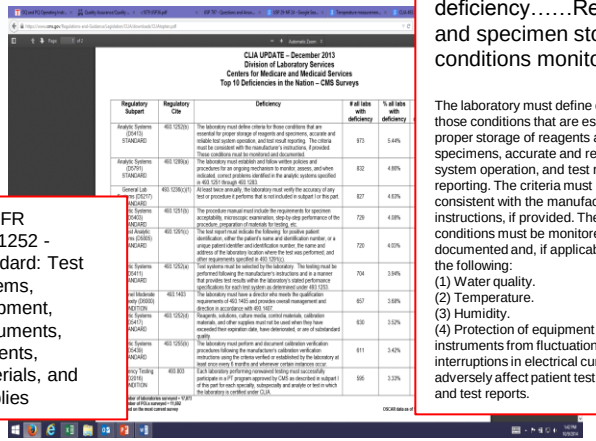
- ISO
- cGMP
- Laboratories maintaining accreditation or certification programs
- Regulated/audited operation or process
  - FDA/USP/USDA/JCAHO/CLIA/CAP

Most all guidelines of these standards call for Individually Serialized, Calibrated and Certified test and measurement instruments.



SPECIMEN STORAGE AND STABILITY
…
2.Separated serum or plasma should not remain at room temperature longer than 8 hours. If assays are not completed within 8 hours, serum or plasma should be stored at +2° C to +8° C. …

REAGENT STORAGE AND STABILITY
ALT reagent when stored unopened at +2° C to +8° C will obtain the shelf-life indicated on the cartridge label. …..



42 CFR 493.1252 - Standard: Test systems, equipment, instruments, reagents, materials, and supplies

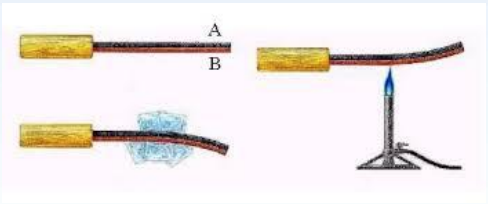
Continuously a top deficiency……Reagent and specimen storage conditions monitoring.

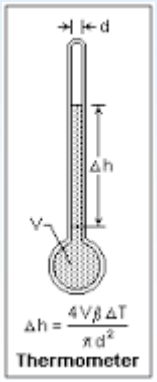
The laboratory must define criteria for those conditions that are essential for proper storage of reagents and specimens, accurate and reliable test system operation, and test result reporting. The criteria must be consistent with the manufacturer's instructions, if provided. These conditions must be monitored and documented and, if applicable, include the following:
(1) Water quality.
(2) Temperature.
(3) Humidity.
(4) Protection of equipment and instruments from fluctuations and interruptions in electrical current that adversely affect patient test results and test reports.

Temperature Measurement Technologies - Analog

Historically, thermometers were mechanical (mostly bi-metal), which evolved into liquid in glass thermometers. However, as technology improved, consistent dimensions in glass manufacturing processes were achieved.

These types of thermometers were able to indicate changes in temperatures, based on the effect of how the material to expanded or contracted, on a fairly linear scale.





Often filled with mercury or other “spirits”

PROS	CONS
Simple to use	Sacrifice accuracy for range
Reliable with high quality manufacturing	User judgment error
Low cost if high accuracy is not required	Hazardous materials often used

Temperature Measurement Technologies - RTD

Digital Thermometers address many shortcomings of mechanical devices. When digital thermometers were first developed, resistance (RTD) was the broad commercially available technology.

Basically RTD, is as the temperature of certain materials is changed, the resistance of that material varies proportionately and predictably. Measuring the changes quantifies the temperature. Different types of materials are affected differently.

Material	Typical Range	Typical Practical Accuracy	Cost
Platinum	-200C to 800C	Up to 0.01C	$$$$
Nickel	-100C to 260C	Up to 0.1C	$$
Thermistor (PTC/NTC)	-50C to 150C	Up to 0.25C	$
Other Materials	Specialized	Applications	

Note: Response time of RTD thermometer readings is most affected by the amount of material used in probe, and probe housing construction. The larger the amount of material, the greater the thermal mass, the slower the response time – conversely the more durable the device.

Temperature Measurement Technologies - Thermocouple

Thermocouple technology has been developed primarily to address high temperature applications, where we are usually willing to sacrifice accuracy for lower costs. Thermocouple probes weld two dissimilar metals together that have a behavior of producing a voltage dependent on temperature. There are other types of thermocouple thermometers, however the most common are:

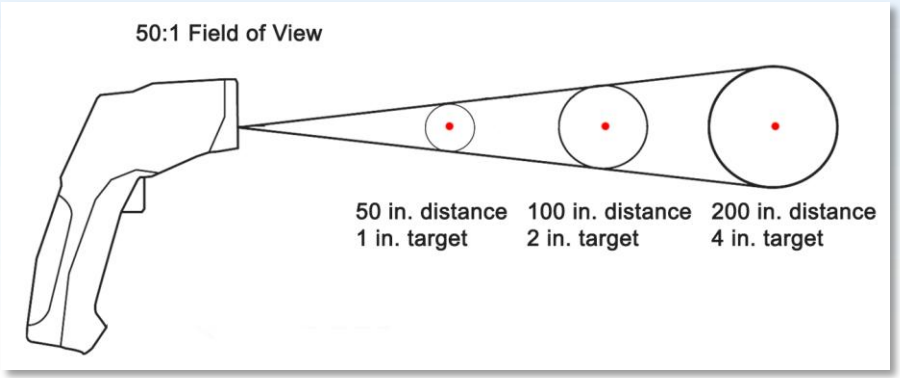
Type/Material	Wire Color	Common Accuracy	Special Accuracy Limit	Range
Type-T Copper Constantan	Blue	1C	0.5C	-200C to 350C
Type-J Iron Constantan	Black	2.2C	1.1C	0C to 780C
Type-K Chromel Alumel	Yellow	2.2C	1.1C	-200C to 1250C

Note: Below -50C, most thermocouple thermometers' performance degrades rapidly, especially with impure materials.
Note: With accuracy limitations typically >1C, most healthcare (regulated, audited and accredited) applications would not recommend thermocouple technologies.

Temperature Measurement Technologies – Infrared

Infrared (IR) thermometers emit an IR signal at a surface, which reflects back to a sensor. The energy of the reflected beam varies based on the temperature of the surface.

IR thermometers **measure surface temperature, not internal temperature**. Temperature measurement of IR thermometers can often go as high as 3000C, with accuracies of the greater of 2C-5C or 2% of the reading.



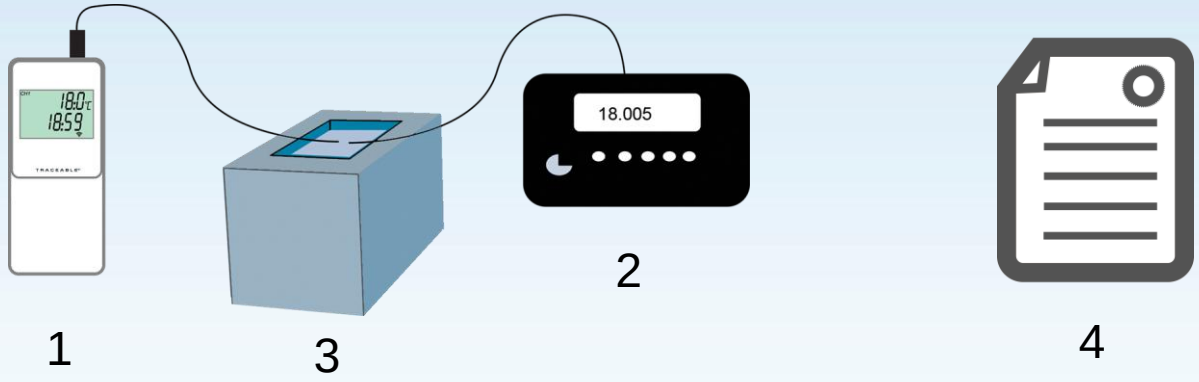
Accuracy at 200°C	D/S Ratio	Price
± 5 °C	1:1	$50
± 4 °C	12:1	$150
± 4 °C	50:1	$300

The significant benefits are that IR thermometers are non contact, that they can take readings at greater distances, and their ability to go to the highest temperatures.

Note: the temperature of the IR thermometer itself has an impact on accuracy of readings. Most devices are calibrated at a standard environmental temperature (typically around 25C).

Temperature Calibrations – How they are typically done

Calibration is a process to validate the performance of a measurement device. In order to validate the performance of each unique unit, you must use in a controlled environment. The more stringent the accuracy and repeatability requirement, the more necessary to calibrate. The process involves unit you are testing (1), another unit to compare it to – generally at least 4x accuracy (2), a controlled standard or medium to measure (3), and a documented process to follow (4).



When you design and manufacture a measurement device, each individual unit will have unique performance characteristics because of variance in materials, variance of assembly, and environmental conditions.

The main influences on that performance are typically:

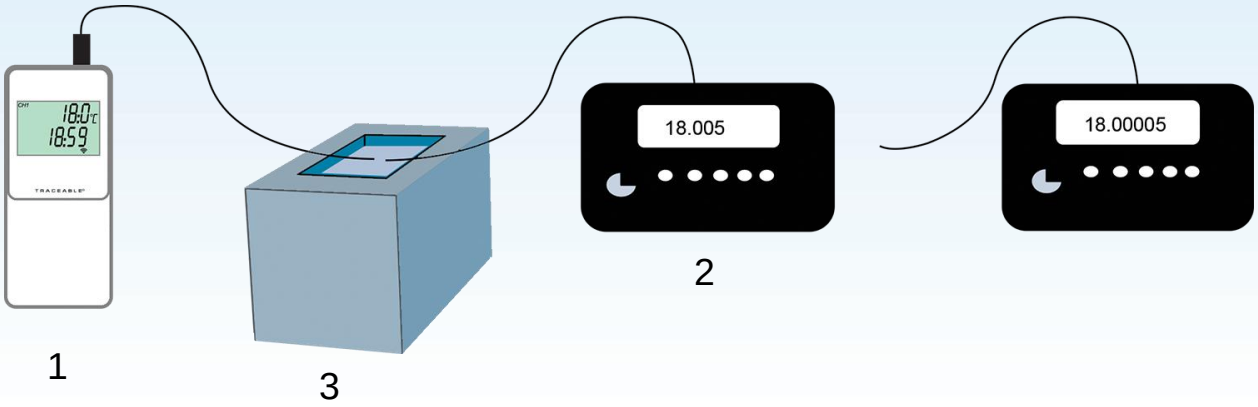
- Sensor - materials, size, and construction
- Probe wire connecting electronics to sensor – size and length, material and dimensional consistency
- The connector joining probe wire to electronics – surface area in contact and resistance

What a calibration certificate would contain

- Stated accuracy of unit for calibration, uncertainty of the unit for calibration
- Uncertainty of process
- Stated estimate of uncertainty of the calibrated instrument
- Standards used for traceability
- Pass or fail annotation

What is traceability in calibration?

In the context of measurement science, traceability is the property of a measurement result in which the result can be related to a national measurement reference through an unbroken chain of calibrations. National measurement standards are maintained by national measurement institutions (NMI's), such as the National Institute of Standards and Technology (NIST) in the US. An ISO/IEC 17025 accredited calibration certificate includes documentation of that unbroken chain of traceability.



National Institute of Standards and Technology

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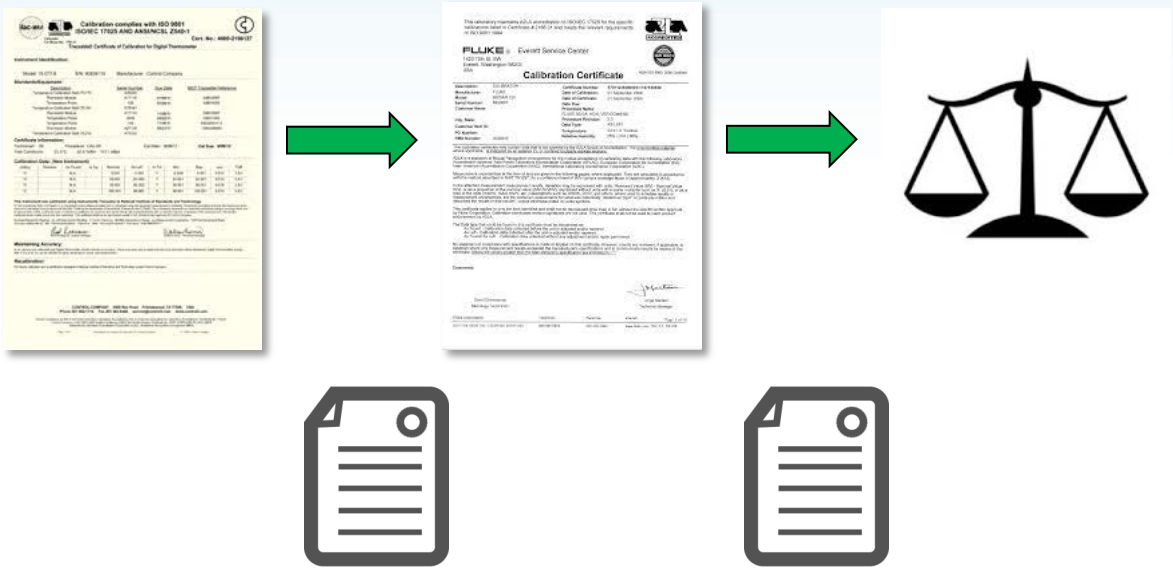
What Is an Accredited Calibration

A calibration process that has been verified by a third party organization with metrology expertise at each step in the chain. This provides a link (Traceability) to national standards that any device is calibrated against.

It ensures that the process:

- Calculates and provides accurate uncertainty estimation
- Identifies the name of accredited procedure or process
- Identifies the standards through which traceability is established
- Displays an accreditation logo
- In addition to providing all information provided for a non accredited calibration



Accredited Calibration Certificate Details

- Individually serialized
- Individually calibrated
- Individually certified, Traceable to NIST

Accredited by A2LA (The American Association for Laboratory Accreditation) dedicated to "one test accepted everywhere, one accreditation accepted everywhere". A2LA is your assurance of internationally recognized technical laboratory competence. A2LA is recognized by ILAC and MRA.

Displays catalog number for complete product reference

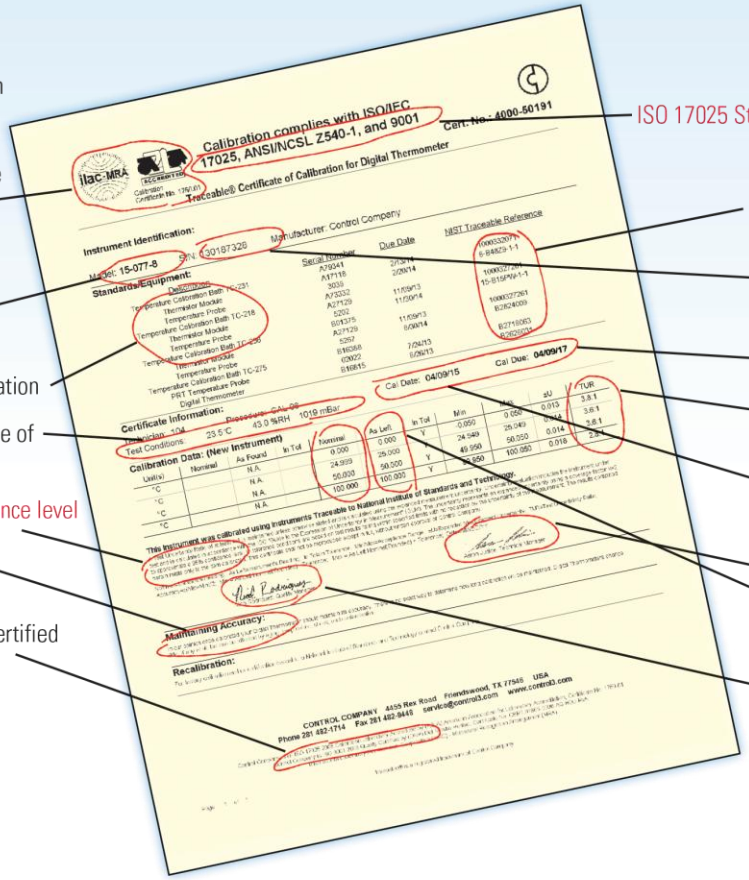
Calls out the test equipment used for calibration

Reports environmental conditions at the time of measurement

Spells out test uncertainty ratio and confidence level

Lists specific conditions that may affect product accuracy

Supplied from an ISO 9001 quality facility certified by DNV



Conforms to universally recognized ISO 17025 Standard, a requirement for any ISO 9000 quality facility

Establishes with reference numbers the unbroken chain of traceability to NIST

Displays serial number for total product identification

Indicates Calibration Due Date

Spells out test uncertainty ratio and confidence level

Specifies Calibration Date when the unit was tested

Signed by the Technical Manager

Provides measurement test results for your specific unit

Signed by the Quality Manager

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Recalibration vs. Retirement

RECALIBRATE if:

- Required by regulatory body or accreditation agency
- Required by your documented process
- $ Unit or device has a high price point
- Desire to have historical archive of consistency of device

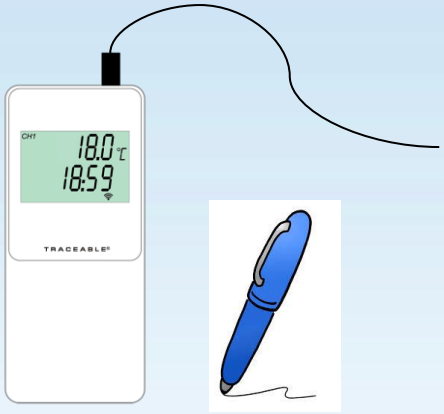
REPLACE if:

- Recalibration cost is significantly higher than replacement cost, and…
- As found/as left data is not required by process, regulation or accreditation
- Note: No need for temporary or backup device to be used during recalibration, and is typically less resource and tracking intensive.

Again, Why Calibrated Test and Measurement Instruments–Benefits

Monitoring – The Drive to Meaningful Data

Temperature Measurement to Temperature Monitoring



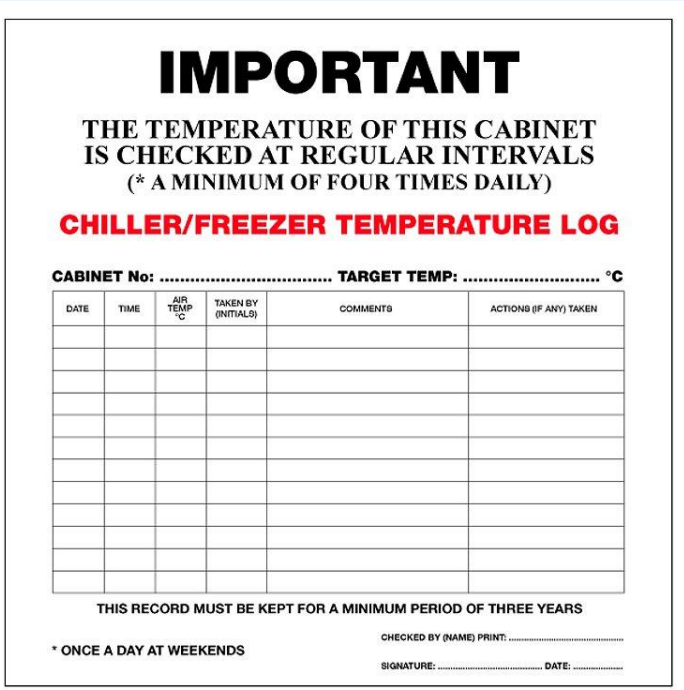
Historically Temperature Monitoring has been done with a thermometer, pen and paper, or with an analog chart recorder.

A person will go to the thermometer and take and record a reading at regular (hopefully) intervals on a log. This data can then be archived or analyzed as needed.

This manual method is also

The greatest potential shortcomings of this method are the risk of human error in reading, recording, or interpreting the information, and the fact that the data is difficult to analyze in its original format.

Note: you need to check for accredited calibrated instrument for critical processes



IMPORTANT

THE TEMPERATURE OF THIS CABINET IS CHECKED AT REGULAR INTERVALS
(* A MINIMUM OF FOUR TIMES DAILY)

CHILLER/FREEZER TEMPERATURE LOG

CABINET No: ..... TARGET TEMP: ..... °C

DATE	TIME	AIR TEMP °C	TAKEN BY (INITIALS)	COMMENTS	ACTIONS (IF ANY) TAKEN

THIS RECORD MUST BE KEPT FOR A MINIMUM PERIOD OF THREE YEARS

* ONCE A DAY AT WEEKENDS

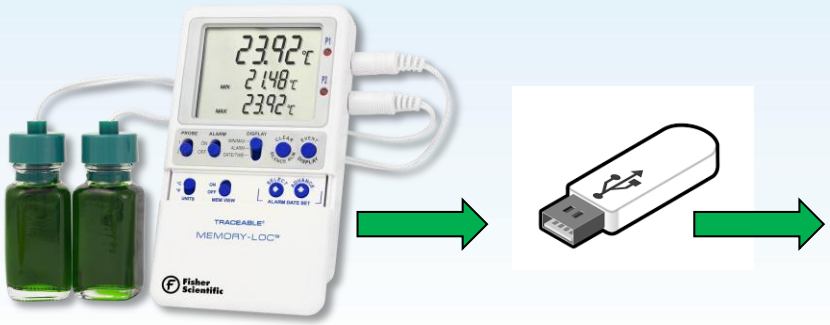
CHECKED BY (NAME) PRINT: .....

SIGNATURE: ..... DATE: .....

Temperature Measurement to Temperature Monitoring

- How it is done now

Device takes readings > Records on internal memory > Data is downloaded and analyzed

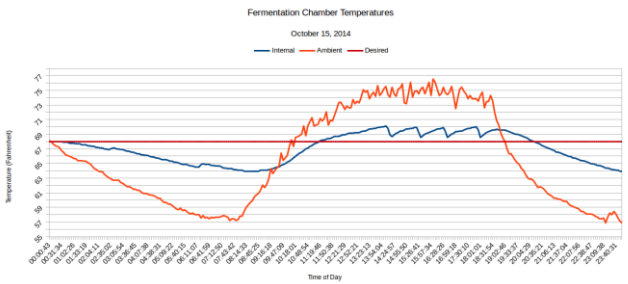


Unique ID for each thermometer, ties to serial number of unit

ID:	D1628C5117242137				
Alarm Event Data					
Probe	Temp	Time Out	Date Out	Time In	Date In
1	8.00	2:01	1/16/2015	4:12	1/16/2015
2	2.00	6:32	2/4/2015	13:47	2/4/2015
Temperature Data					
P1	P2	Time	Date		
22.92	22.75	2:46	1/7/2015		
22.91	22.71	2:45	1/7/2015		
22.92	22.71	2:44	1/7/2015		
22.93	22.71	2:43	1/7/2015		
22.92	22.71	2:42	1/7/2015		
22.92	22.69	2:41	1/7/2015		
22.92	22.71	2:40	1/7/2015		
22.92	22.69	2:39	1/7/2015		
22.91	22.71	2:38	1/7/2015		
22.89	22.69	2:37	1/7/2015		

Exact temp readings of probe(s) with time and date stamp

Exact time and date when unit went outside of user-defined set points and when the unit came back into range



Note: You need to check for accredited calibrated instrument for critical processes.

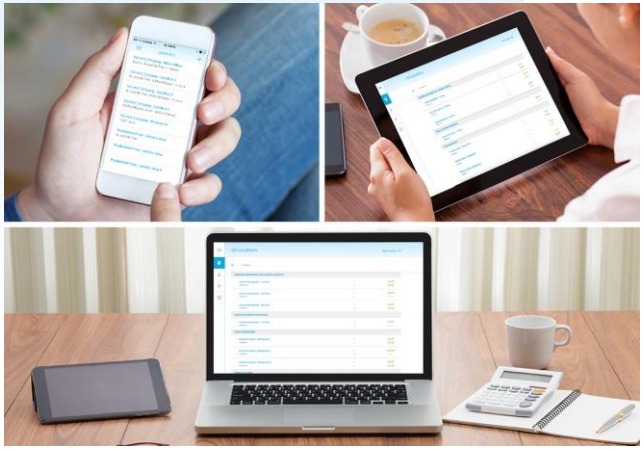
Temperature Measurement to Temperature Monitoring

- Some key things to look for in a data-logging device
  - Individually serialized, calibrated and certified – traceable to NIST
  - Number of temperature readings that the unit can store on the device
  - User-defined timing intervals
  - Ease of transferring and importing data into computer
  - Detailed data output, not only summary data
  - Appropriate temperature range with tight accuracy specifications
  - Alarm event information captured and highlighted on data output
  - Additional software and hardware requirements
  - Ability for the thermometer to continue to monitor temperature while data is being transferred
  - Alarm indicators for active alarm state, low battery and memory full
  - Ability to clear memory on the device once data is transferred or ability to not clear for archive purposes

Temperature Measurement to Temperature Monitoring

- How will be done tomorrow:

Device takes readings > Communicates those readings to a cloud database, which stores the data > Gives you real-time access and visibility from anywhere, as well as the ability to get remote notifications of alarm events.



Note: You need to check for accredited calibrated instrument for critical processes.

Temperature Measurement to Temperature Monitoring

- Key things to look for in a monitoring system
  - Individually serialized, calibrated and certified – Traceable to NIST
  - Remote alarm notifications, and “on device” alarm notification
  - Ease of installation, setup
  - Ability to access data and to set alarm parameters for device remotely, and…
    Ability to require “on device”, not remote acknowledgement of alarms
  - Receive multiple format alarm notifications for temperature alarms, loss of connectivity and low battery
  - Cloud-based data interface
  - Scalability based on your needs
  - Reporting – data output needs
  - Assignability of administrative and non-administrative user access

Thank You

If you want further information or help in finding the best solution for your application, please contact your local Fisher Sales Representative