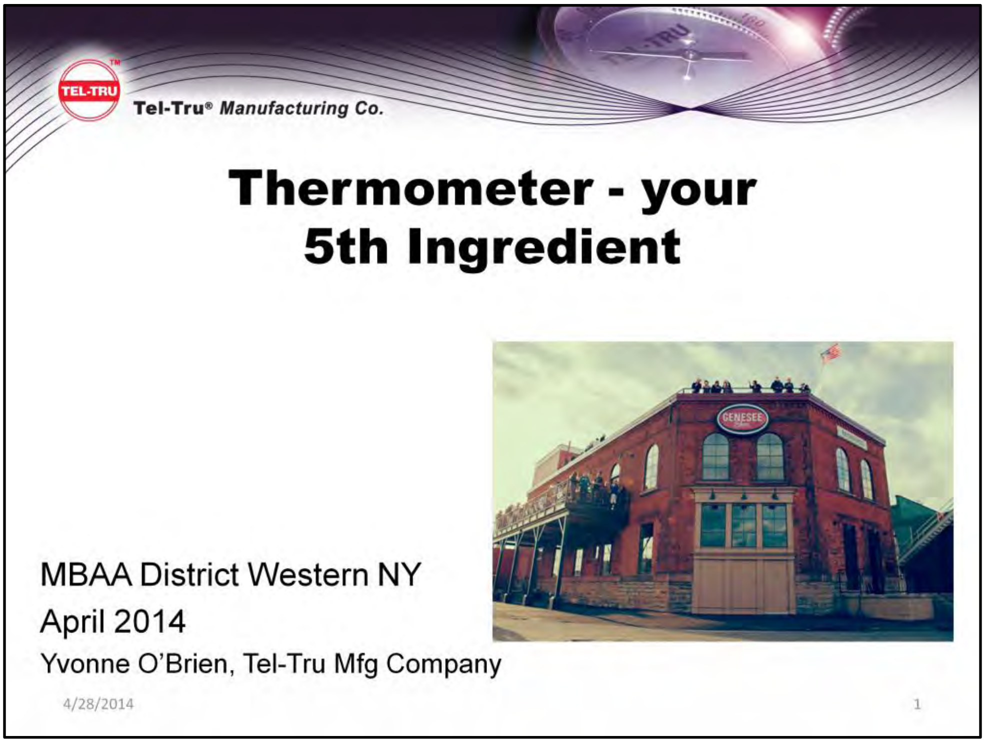

Thank you for this opportunity to present to your group. A little background, I have worked for Tel-Tru for over 30 years learning the manufacturing process and helping customers with their thermometer requirements. Tel-Tru manufacturers temperature & pressure instruments, both mechanical and electronic. Tel-Tru is 98 years old and our factory is right across the street on St Paul.

Your beer batch take weeks to process and during the process you are changing and monitoring your temperatures so that your brew has the right body, the right mouth feel, and the right alcohol level for the style of beer that you are making. You measure temperature at every step of the brewing process from drying the grain to fermentation and storage so your Thermometers are pretty darn important…your 5th ingredient.

Tel-Tru® Manufacturing Co.

Temperature Instruments in Microbrewery and Commercial Brewery

Small Microbrewery	Larger Microbrewery or Commercial Brewery
Local Indication	**Remotely wired to programmable computerized or logic control system with Local Indication for back-up**
•Bimetal Thermometers •Digital Thermometers •Glass Industrial Thermometers (being phased out)	•Remote Instruments •Temperature Transmitter •RTD probes •Thermocouples •Thermistors •Local Indicators: •Bimetal Thermometers •Digital Thermometers

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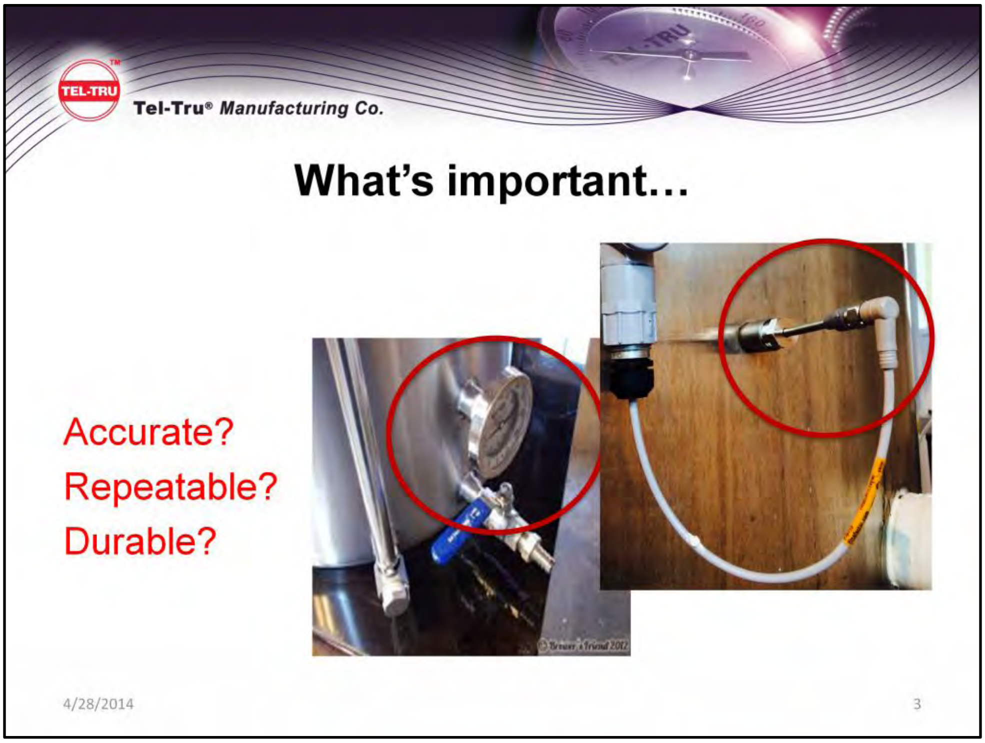
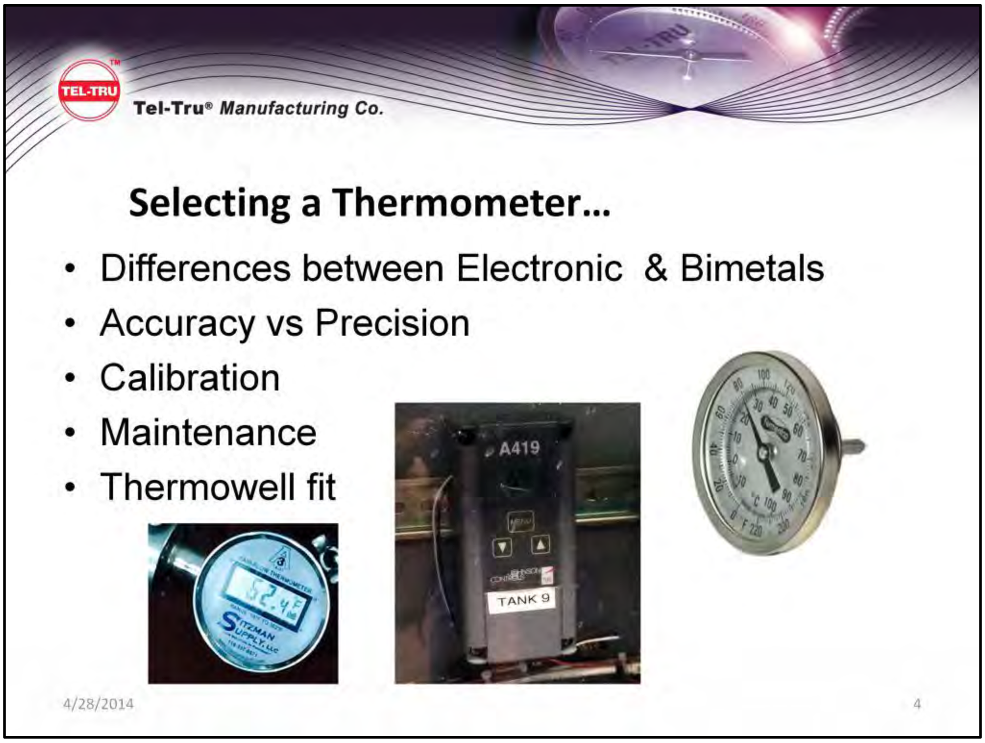
The instruments you use are as important as the ingredients…Accurate and controlled temperatures during your brewing process will contribute to making a great beer. From setting the sparge and mash temperatures to fermentation and storage. Your thermometer selection is a basic ingredient to making your brew a success.

In the larger microbreweries and commercial breweries I find electronic temperature instruments that are remotely wired to an electronic display or logic control system. In addition they have local temperature indicators for comparison and back-up. The smaller micro-breweries may only use local indicators such as bimets or digital thermometers.



The photo on the right is of an electronic temperature probe with quick disconnect wire that leads to an electronic display panel. The photo on the left shows a bimetal thermometer for local indication. Everyone wants a thermometer that is accurate, repeatable, and durable for their process. Most people tend to forget response time and easy maintenance until after they purchase their thermometers.



I am going to cover a few differences between electronic & bimetal thermometers.
I will explain accuracy vs precision, and do a light overview on calibration, maintenance, and Thermometer & Thermowell fit.

The images on the bottom left shows 2 different digital thermometers with different housings and possibly different temperature sensors.

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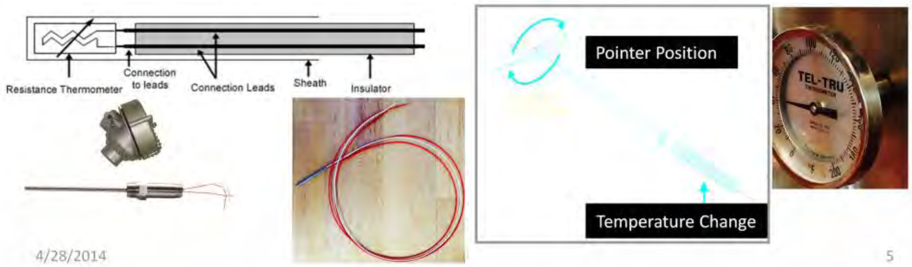
RTD vs Bimetal

RTD Temperature Probes	Bimetal Thermometers
DC Power	Self Powered
Local & Remote reading	Local reading
Displayed number	Pointer positioning
(Ω) R vs T	Angular deflection



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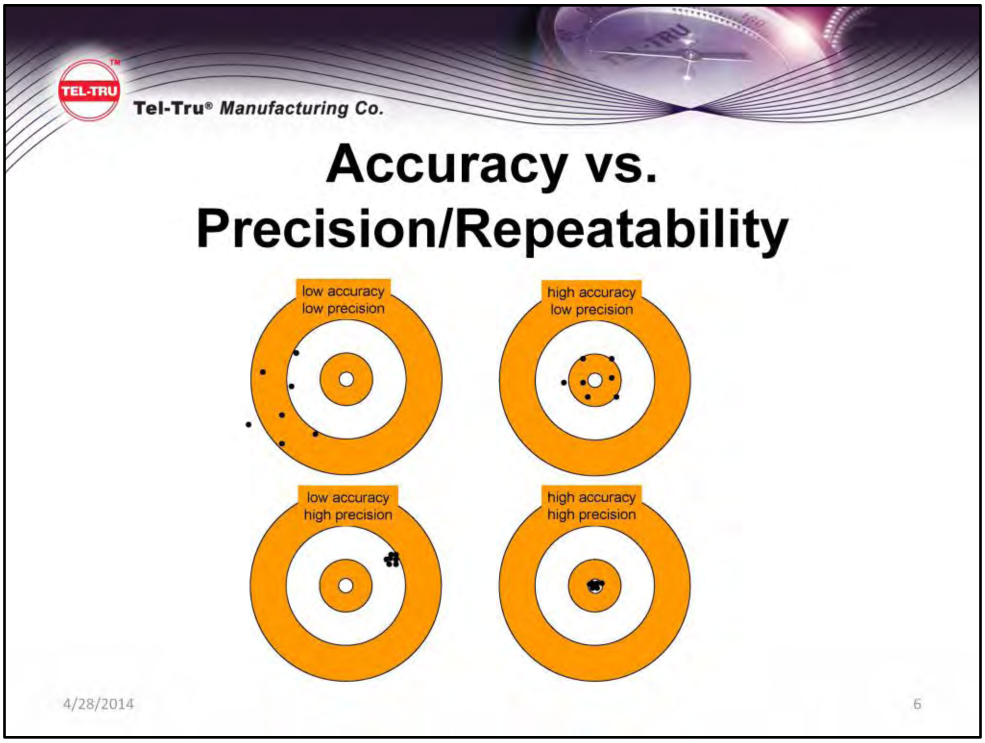
RTD temperature probes are widely used because of their accuracy and repeatability. RTD's are typically made with platinum wire elements, an electrical resistance source. An electronic circuit is used to convert the resistance value into a temperature reading. The change in electrical resistance is indicated as a temperature reading on a digital display or meter.

Bimetal thermometers are widely used for local monitoring because they do not require any electrical power and are quite durable. The sensing element is constructed out of 2 dissimilar metals fused together and wound into a helix coil. The bimetal coil will expand and contract with change in temperature. The angular deflection is measured and matched to a dial graduation layout.

RTD & Bimetal sensors require that the entire sensing element be immersed into the process for accurate readings.



Targets are visual aid to show…
Accuracy, the location of the dots compared to the center of the target
Precision, the spread of the dots and how they vary from each other.

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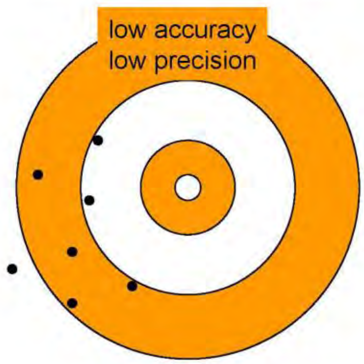
Low Accuracy & Low Precision/Repeatability

Thermometer +/- 2°F (38°F to 42°F)



Accuracy	Bad
Precision	Bad
1	43.0
2	42.5
3	44.0
4	45.5
5	43.5
6	41.0
7	44.5
Ref. Temp.	40°F
Avg	43.43
Std Dev (σ)	1.456
6σ	8.734

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Accuracy = reading compared to the mfrs accuracy spec. (Target dot location in relation to the center of the target)
Precision = reading variation (Target dot spread)
Standard deviation = how much variation exists in the readings. When the data points are spread apart the standard deviation is great.
Six Sigma = 6x standard deviation and I am looking for a number that is equal or less than the thermometer tolerance number. For this example I indicated the thermometer tolerance as ± 2 degrees F.

Exercise method: 1 thermometer is tested 7 times in a certified bath temperature that is 40°F and readings recorded.

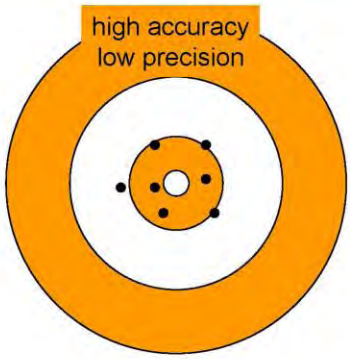
Readings of this this thermometer varied from 41°F to 45.5°F, This thermometer has bad accuracy because the average reading is 43.43°F.

The thermometer also has bad precision because the readings vary to greatly from each other.

6 Sigma = 8.734 and is greater than ± 2 degrees F so we know that our precision is bad.

High Accuracy & Low Precision/Repeatability

Thermometer +/- 2°F (38°F to 42°F)



Accuracy	Good
Precision	Bad
1	42.5
2	39.0
3	39.5
4	40.5
5	39.0
6	38.0
7	41.5
Ref. Temp.	40°F
Avg	40.00
Std Dev (σ)	1.581
6σ	9.487

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Accuracy = reading compared to the mfrs accuracy spec. (Target dot location in relation to the center of the target)
Precision = reading variation (Target dot spread)
Standard deviation = how much variation exists. When the data points are spread apart the standard deviation is great.
Six Sigma = 6x standard deviation and I am looking for a number that is equal or less than the thermometer tolerance number of ± 2 degrees F.

Exercise method: 1 thermometer is tested 7 times in a certified bath temperature that is 40°F and readings recorded.

Readings of this this thermometer varied from 38°F to 42.5°F. This thermometer has good accuracy because the average reading is 40°F.

The thermometer has bad precision because the readings still vary too much from each other.

6 Sigma = 9.487 and is still greater than ± 2 degrees F and confirms our precision is bad.

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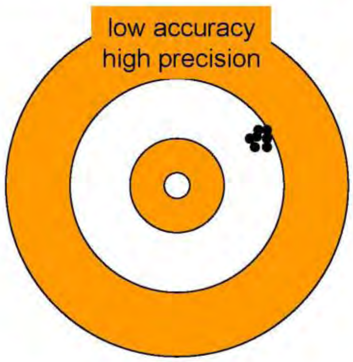
Low Accuracy & High Precision/Repeatability

Thermometer +/- 2°F (38°F to 42°F)



Accuracy	Bad
Precision	Good
1	43.5
2	43.0
3	43.5
4	43.0
5	43.0
6	43.5
7	43.0
Ref. Temp.	40°F
Avg	43.21
Std Dev (σ)	0.267
6σ	1.604

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Accuracy = reading compared to the mfrs accuracy spec. (Target dot location in relation to the center of the target)
Precision = reading variation (Target dot spread)
Standard deviation = how much variation exists. When the data points are spread apart the standard deviation is great.
Six Sigma = 6x standard deviation and I am looking for a number is equal or less then the thermometer tolerance numberof 2 degrees F.

1 thermometer tested 7 times and it's temperature reading recorded each time.
The certified reference temperature is 40F.

Readings of this this thermometer varied from 43F to 43.5F, This thermometer has bad accuracy because the average reading is 43.21F and outside it's accuracy tolerance. Yet, the thermometer has good precision because the readings are fairly repeatable without much variation. The 6 sigma number is 1.604 and is less than the 2 deg F spec. which means that this thermometer has repeatability.

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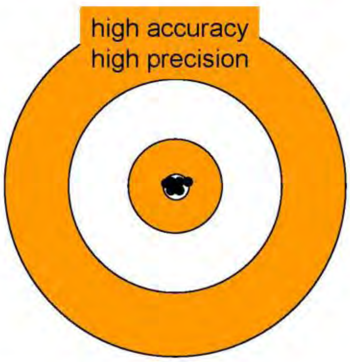
High Accuracy & High Precision/Repeatability

Thermometer +/- 2°F (38°F to 42°F)



Accuracy	Good
Precision	Good
1	40.0
2	40.5
3	40.0
4	40.0
5	40.5
6	40.0
7	40.0
Ref. Temp.	40°F
Avg	40.14
Std Dev (σ)	0.244
6σ	1.464

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Accuracy = reading compared to the mfrs accuracy spec. (Target dot location in relation to the center of the target)
Precision = reading variation (Target dot spread)
Standard deviation = how much variation exists. When the data points are spread apart the standard deviation is great.
Six Sigma = 6x standard deviation and I am looking for a number is equal or less then the thermometer tolerance number 2 degrees F.

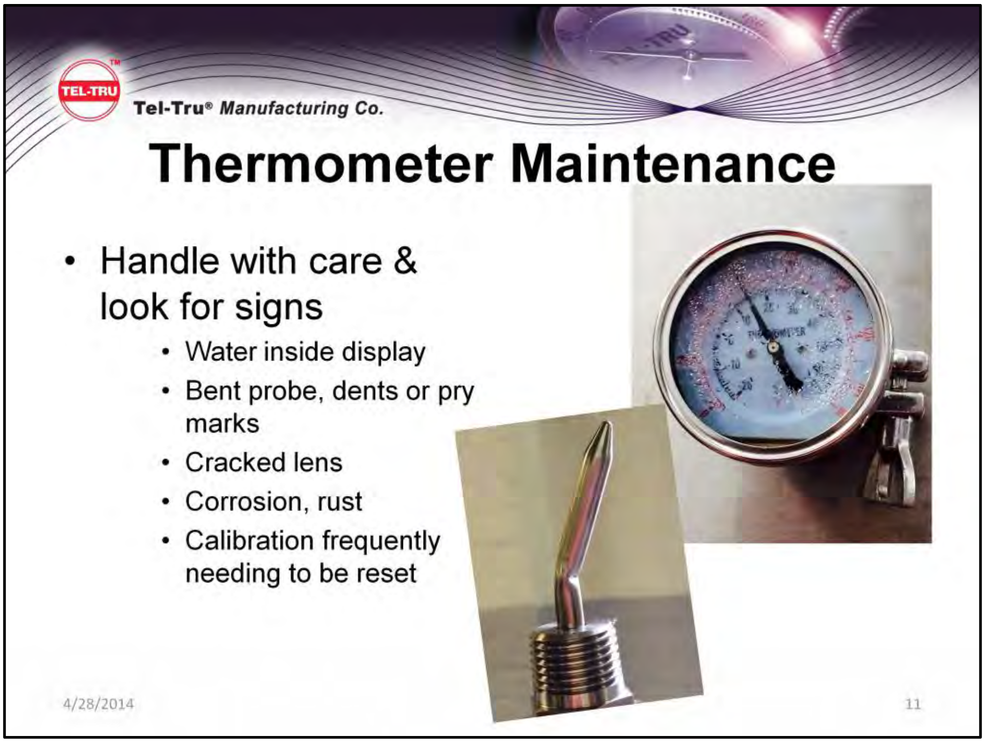
1 thermometer tested 7 times and it's temperature reading recorded each time.
The certified reference temperature is 40°F.

This thermometer has Good accuracy and Good precision because the thermometer average reading is 40.14 and the readings have very little deviation from each other.

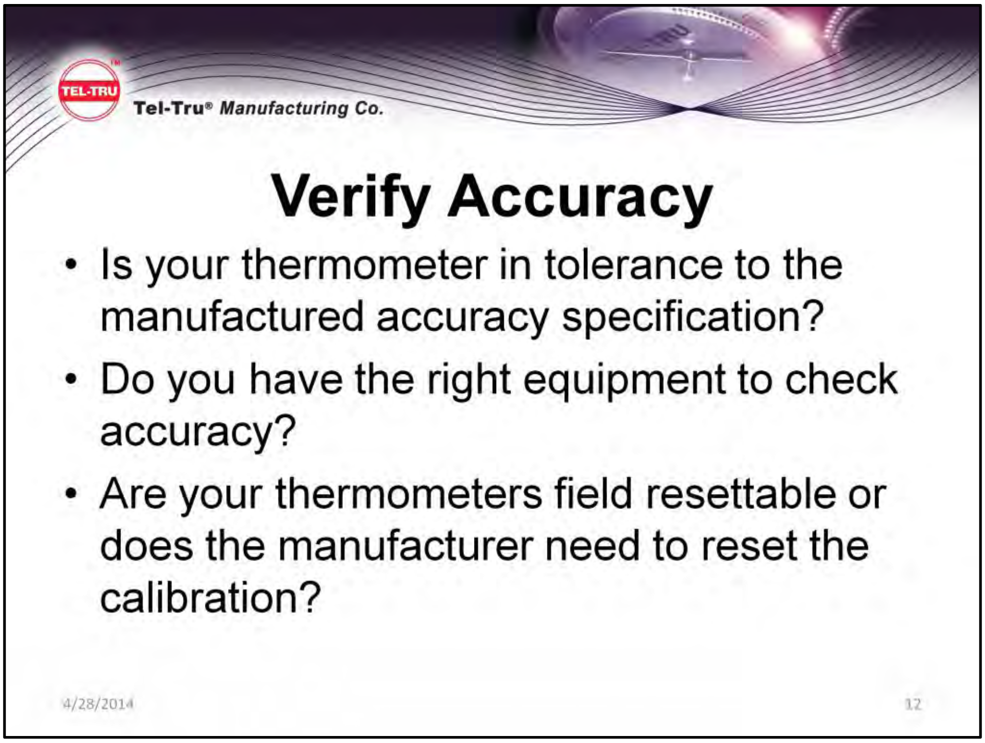
6 Sigma = 1.464 and is less then the manufacturing tolerance 2 degrees F. so again this thermometer is repeatable which means that it is precise.

Your reference temperature device should be at least 4x more accurate then the accuracy standard of the thermometer being tested. When taking the reading of the tested thermometer you need to include the accuracy tolerance of the reference device in the total variable number. So if your tested thermometer tolerance is ± 2 Deg F and the reference device is ± 0.5 Deg F, your total accuracy = 2.5 Deg F.

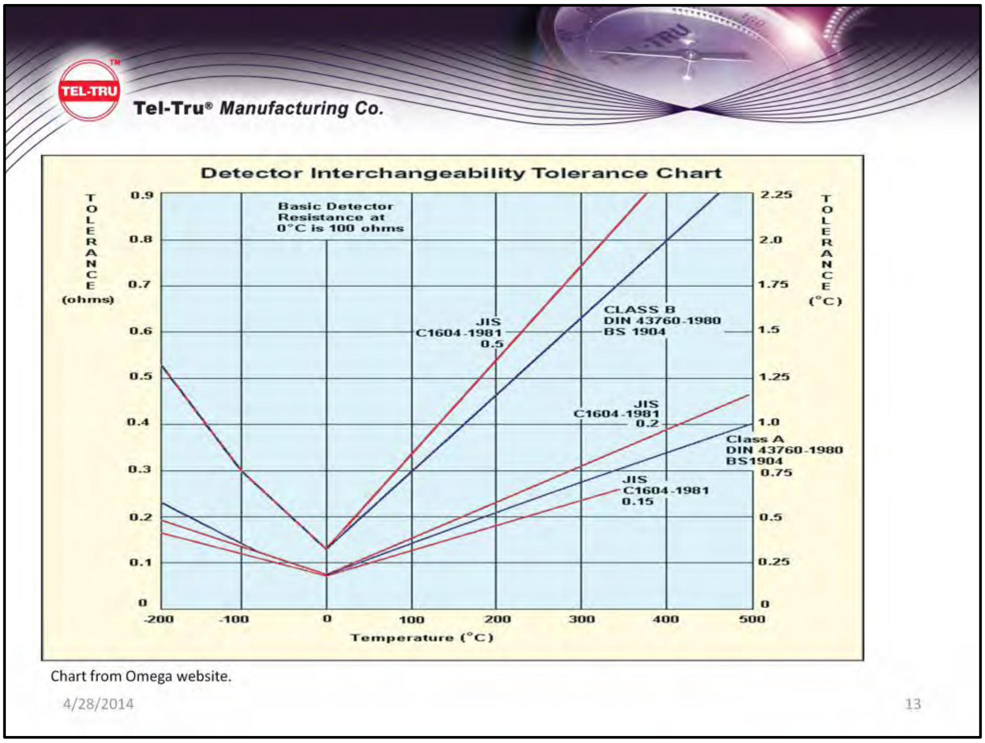
You can improve the quality of a process by reducing variation.



Thermometers are calibrated instruments – that need to be handled with care. Look for visible signs of a problem such as water inside the case.
The photo of the thermometer with water inside the case was taken at a brewery. The thermometer may be fine right now but the water inside will cause deterioration of the internal components and the thermometer will need to be replaced at some point and ideally without affecting your brew.
If you are resetting calibration frequently you may also have a problem thermometer.

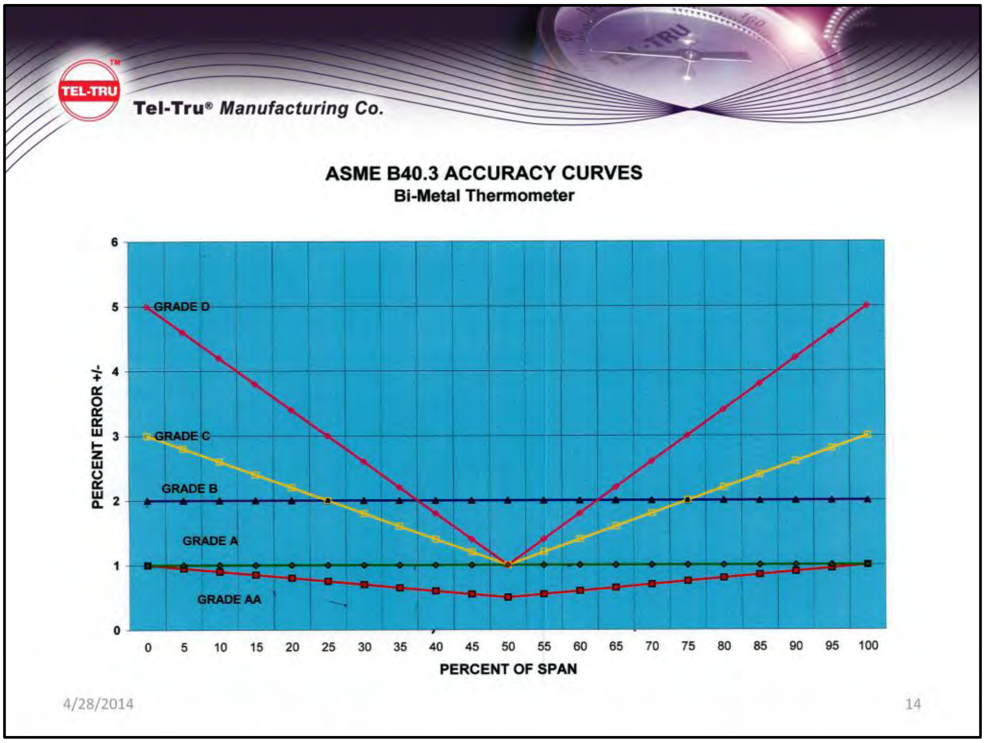


When considering thermometer calibration you will need to know…
The accuracy spec stated my the manufacturer.
Do you have traceable or a known reference to compare your thermometer accuracy to?
If the thermometer is out of accuracy can you reset the accuracy?

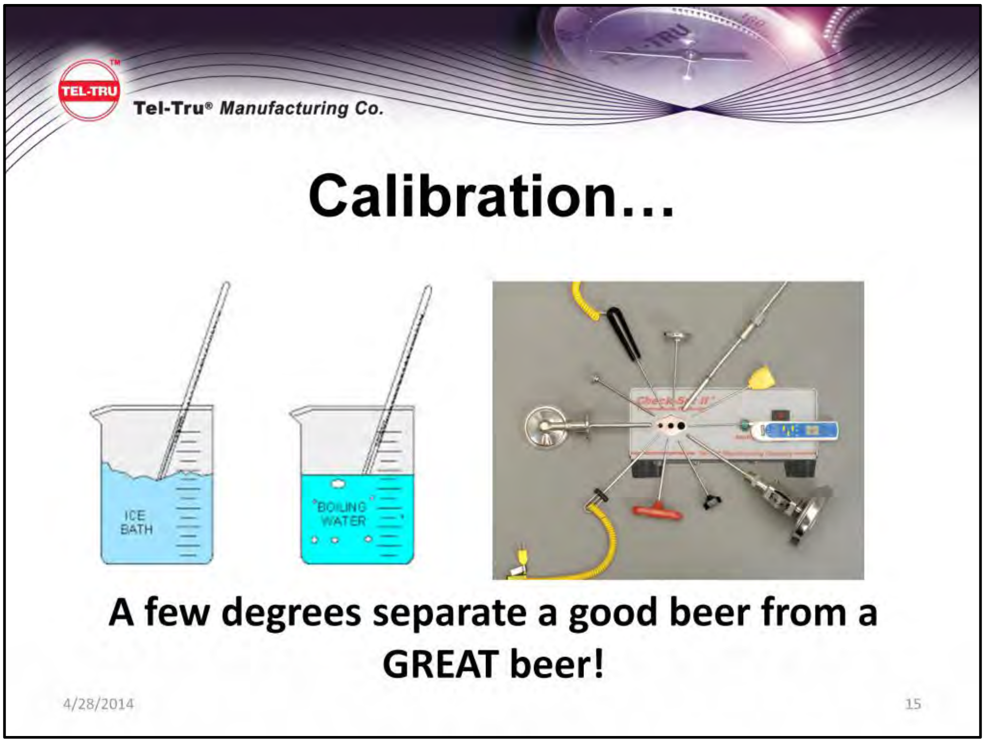


RTD sensors are specified according to their resistance in ohms at zero degrees Celsius. A PT100 element measures 100 ohms at 0° C . The electrical resistance measured in ohms increases as temperature increases. Prompting a repeatable resistance versus temperature relationship.

The DIN standard class A sensor is fairly common in USA. Once you mate the sensor with a transmitter or display you move into your system accuracy.



The accuracy curves for bimetal thermometers is shown in this chart. The Grade A = +/-1% full span and is common in the USA. The grade AA is achievable by manufacturers that make their own bimetal coils.



Consideration for Accuracy verification and calibration:
Do you have a reference device with certified traceable accuracy such as ASTM thermometer or Dry block calibrator?
When preparing ice bath or boiling water, do you use distilled water and ice cubes? The impurities in tap water can lower the temperature, especially important when using a boiling water method for calibration.
Can you agitate the liquid baths to ensure you have temperature consistency around the sensor?
Do you have full immersion of the sensor into the liquid bath or dry block temperature zone. Do you know where your sensor is located and its length inside the probe or stem. Make sure the sensor stays fully immersed while making calibration adjustments.

With ice or boiling water, you will need to ensure that you complete your calibration process without interruption. Dry block calibration or electronic calibration baths allow you more freedom and less error prone.

Boiling point is 212°F at 0 feet above sea level. Make sure that you consider the altitude of your location as well as the barometric pressure at the time of calibration.

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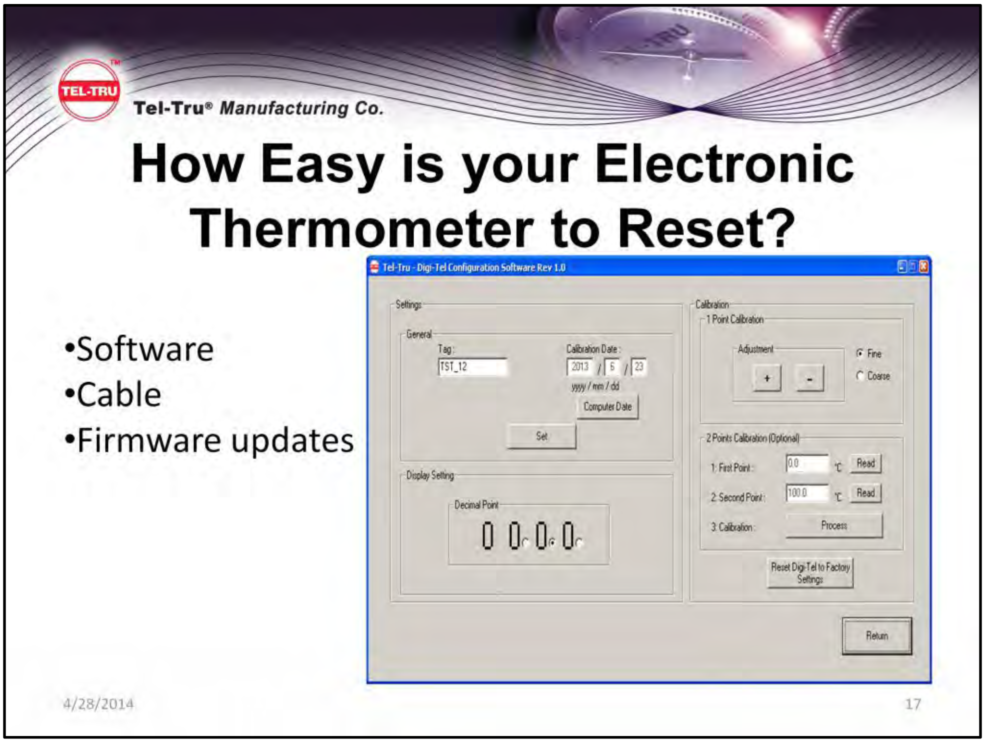
Water Altitude Boiling Point

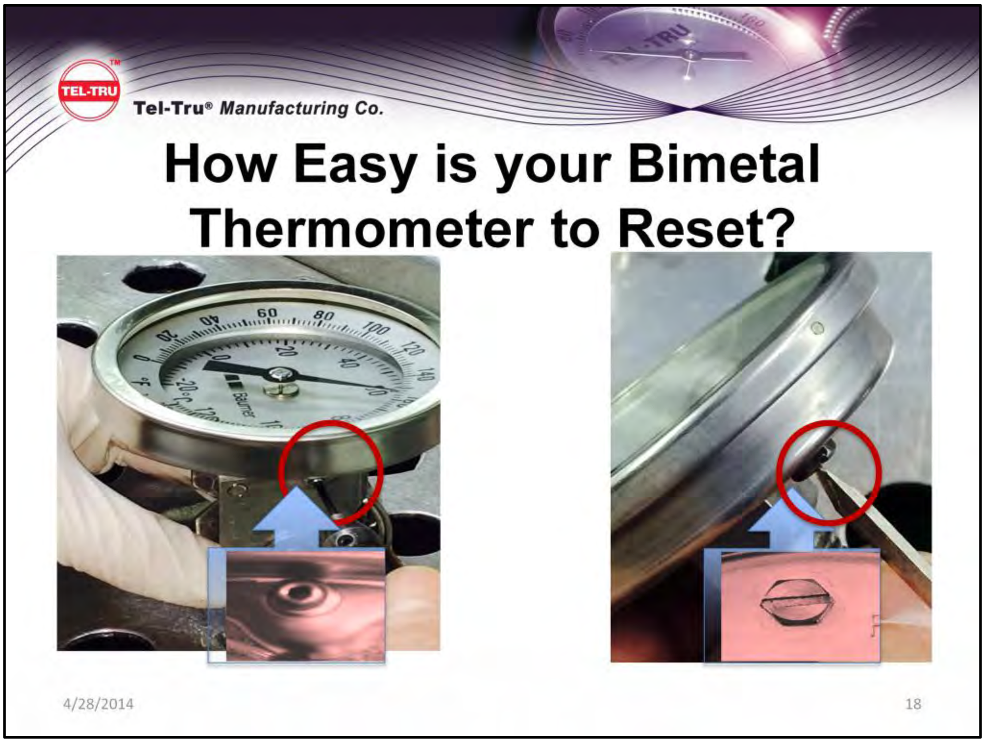
Location	Altitude compared to Sea Level	Boiling Point At a barometric pressure of 29.92 inches of mercury (standard pressure at sea level)
Rochester NY	505 ft	211°F
NY State (mean)	1,000 Ft	210°F
Mt. Marcy	5,343 ft	202°F
Atlantic Ocean	0 ft	212°F

References:
http://www.netstate.com/states/geography/mapcom/ny_mapscom.htm
http://www.csgnetwork.com/h2oboilcalc.html

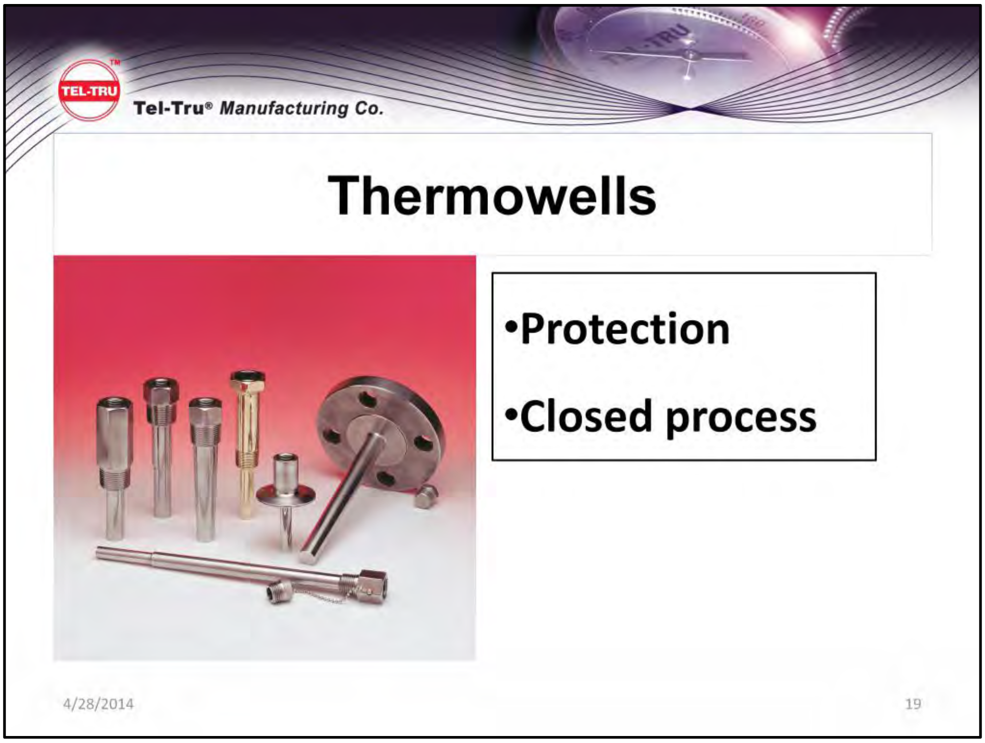
This chart outlines locations in New York state and the altitudes and boiling points using the barometric pressure 29.92 inches of mercury (standard pressure at sea level). As the pressure rises so does the boiling temperature point. At 30.19 hg your boiling point in Rochester NY would be 212.5F



Digital thermometers may be field re-calibrateable. Check with your manufacturer to learn availability. You may also want to confirm if there are any firmware updates for your electronic thermometers.

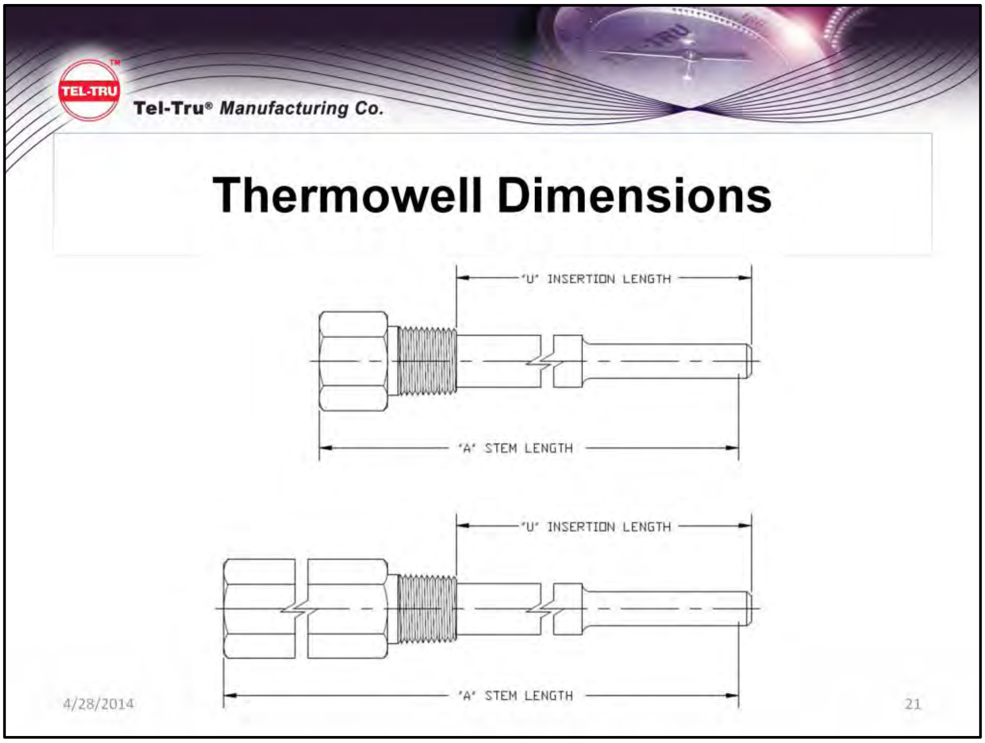


Pictures show thermometers with external reset feature. The image on the right is a bimetal thermometer with a slotted screw that is located at the back of the case. You will need to tilt the case to position your screw driver when resetting. The image on the left shows a bimetal thermometer with the reset hole located at the side of the case which allows the user to more accurately read the pointer position while doing the calibration adjustment.



Installing a thermowell will help protect your thermometer and allow you to remove the thermometer without shutting down your process or draining your tank.
A Thermowell is a drilled out piece of solid metal barstock that is machined with a process connection and shank suitable to the process conditions and fit with your instrument.

Image shows a thermowell shank inside a mash tank. This portion of the thermowell is called the insertion length. Be sure to consider the ideal location and position for your Thermowell before installation. You also want to ensure that there are no moving parts inside the tank that will come in contact with the well.

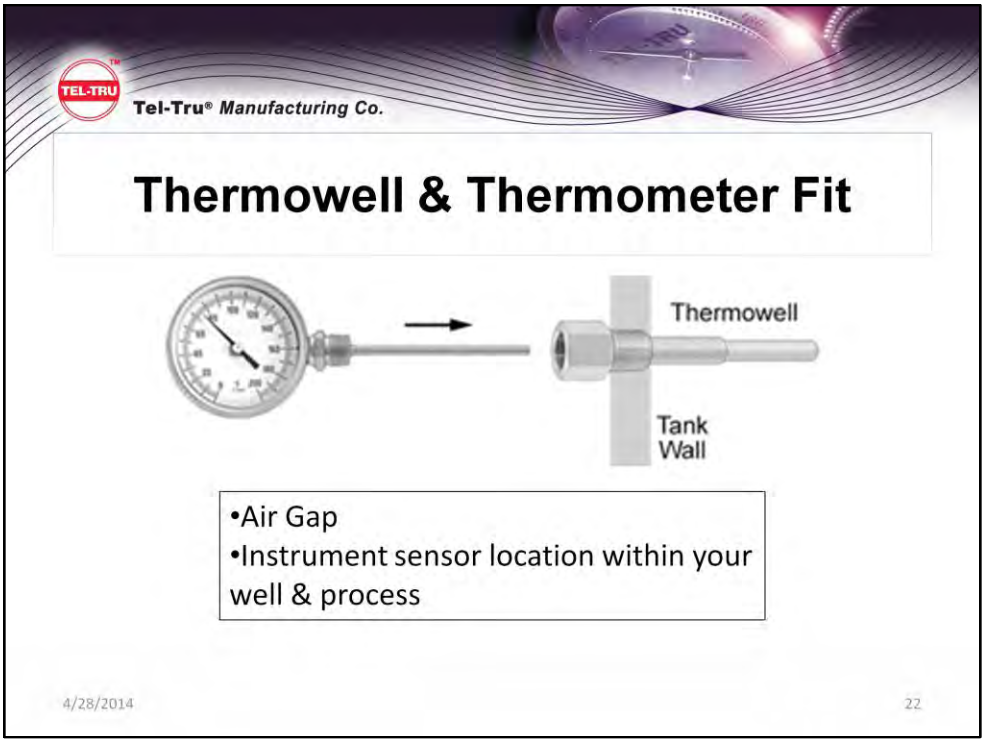


These illustrations show a well with and without a lagging extension. A lagging extension is common when there is insulation or you want the head of your instrument further away from the process.

Stepped and tapered shanks are common specified to improve temperature transfer and response time

The insertion dimension is measured from the underside of the process connection.

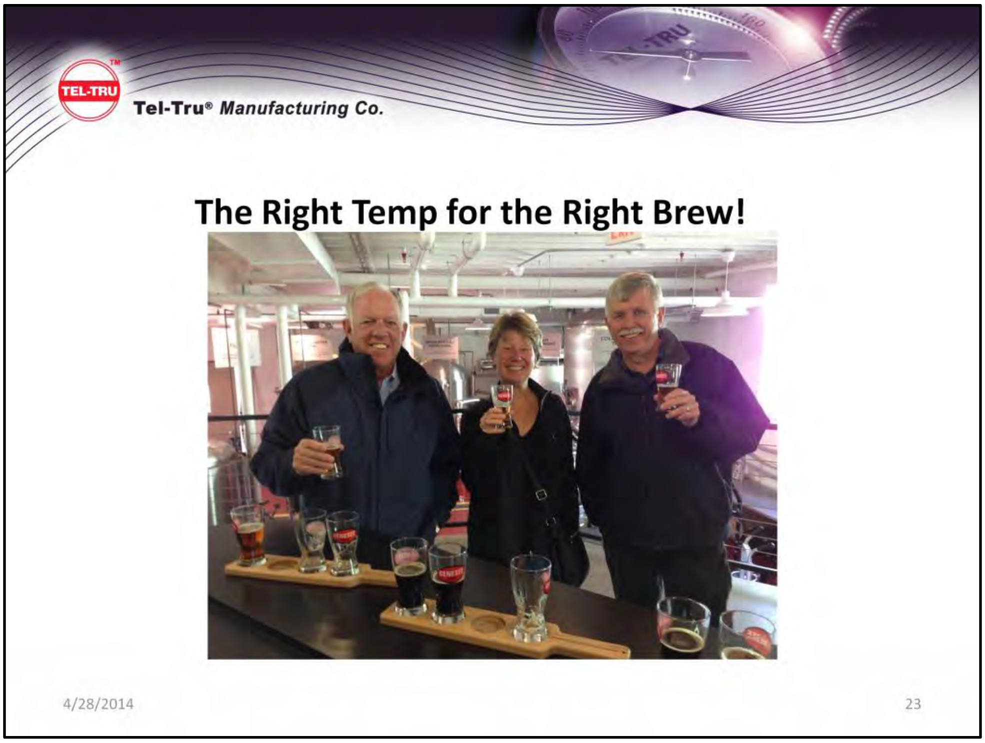
The instrument stem length is based on the Thermowell overall length less the well tip.



Temperature transfer from the thermowell to thermometer can be slowed by the air gap between them, and delay the thermometer reading response time.

Most USA thermometers have a 0.250" probe diameter and the thermowell instrument ID is 0.260". European instruments are more commonly manufactured with a 0.236" probe diameter and installed into a 0.260" bored Thermoewell. To improve the temperature transfer you can use a heat transfer compound around the thermometer probe covering the area where the sensing element is before inserting the thermometer into the thermowell. A bimetal thermometer sensor is commonly 2 to 3" long and located at the end of the probe. Bimetal thermometer probes have a groove or dot indented into the probe to indicate where the sensor begins. The RTD sensor is commonly ¾" to 1" long and located at the end of the probe.

Be sure that your thermometer sensor is completely inside the 'u' area of the thermowell and inside the process so that it is exposed to the process.



I hope that the information helps you in having “The Right Temp for the Right Brew!”

Tel-Tru® Manufacturing Co.

Questions?

Tel-Tru® Manufacturing Co.

Thank You!

Rich Michaels,
MBAA District Technical Chair

Genesee Brew House

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Thank you Rich Michaels and the Genesee Brewhouse for allowing me the opportunity to present at your MBAA event.

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Tel-Tru Manufacturing team

Please visit our websites for more information:
www.TelTrubrew.com
www.TelTru.com