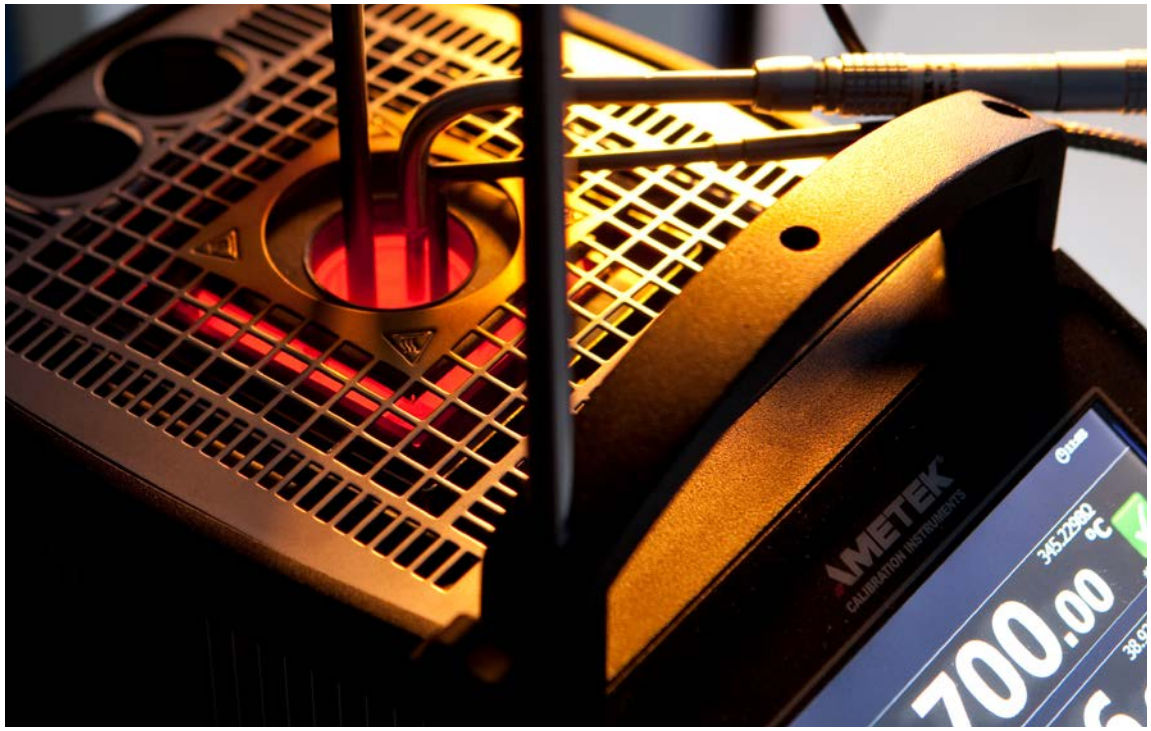


- Calibrate multiple, odd-sized or large sensors without compromising the accuracy.
- Improved and detailed uncertainty budget calculations.
- Three times more accurate than normal dry block calibration.

Dynamic Load Compensation

JOFRA is continuously seeking new ways to improve temperature calibration. The patented Dynamic Load Compensation (DLC) calibration technology is yet another state of the art innovation within temperature calibration.

What is the DLC System?

The DLC system combines a measuring and control system with a newly developed Dynamic Load sensor. It was created to reduce a major contributor to calibration errors.

A dry-block instrument has some inherent error mechanisms, including the affect on calibration accuracy that a sensor under test may add. The sensor transmits energy to and from the calibrator. This heat exchange between the calibrator and the environment has a considerable negative impact on the calibration accuracy. The extent of the error depends on many factors, including sensor size (diameter and length), number of sensors in the well, and the difference between calibration temperature and ambient temperature.

In other words, calibration accuracy is directly influenced by the actual load of the calibrator.

DLC Sensor

RTC-Series Temperature Calibrators

How Does the DLC System Work?

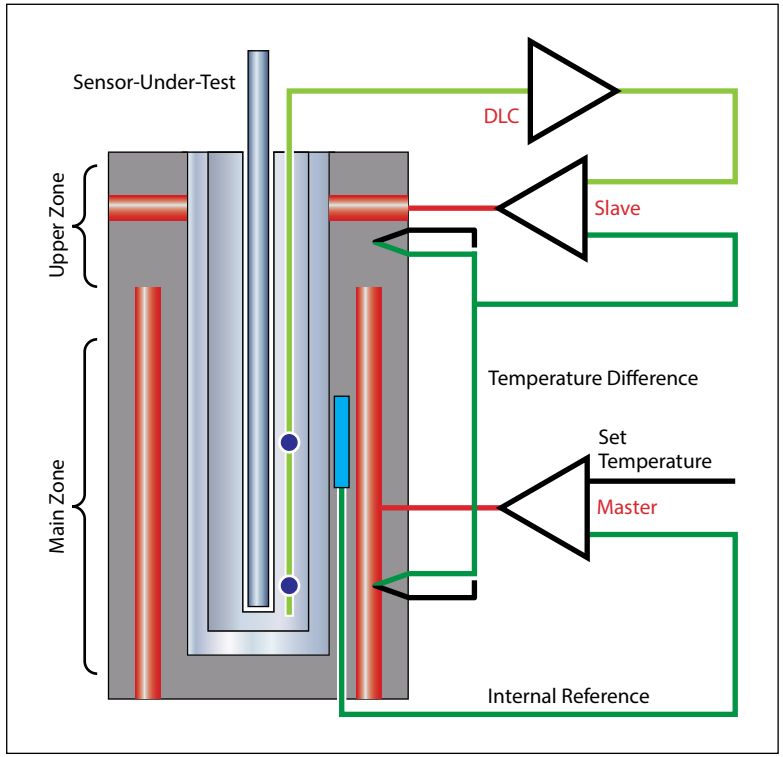
JOFRA temperature calibrators are already famous for their active dual-zone calibration principle.

With the DLC system, we have taken this well-proven and acknowledged dual-zone principle one step further. The load compensation is now active both within the heating block and inside the insert during calibration.

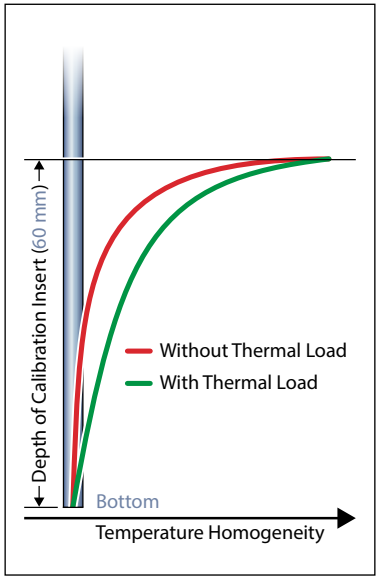
The DLC sensor measures the actual temperature difference between two defined points inside the insert.

The DLC sensor is designed to provide input to the heat control system of the calibrator to ensure that the axial gradient deviations in the lower 60 mm of the insert are kept to a minimum. The temperature difference between the bottom and the zone at 60 mm from the bottom is controlled within a few hundredths of a degree.

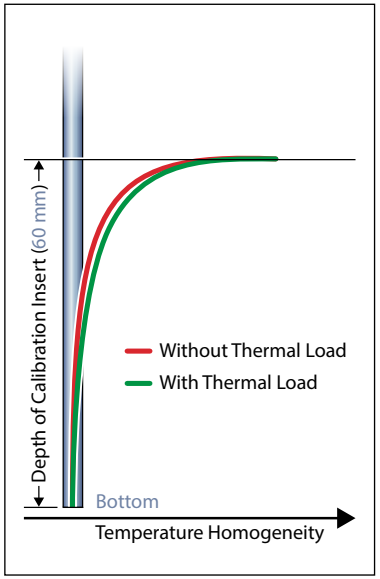
The DLC system reacts immediately to changes in the load of the insert and controls the heat distribution to achieve the minimum axial gradient.



● — Two defined points within the insert.



Single Zone Calibrator



Dual Zone Calibrator

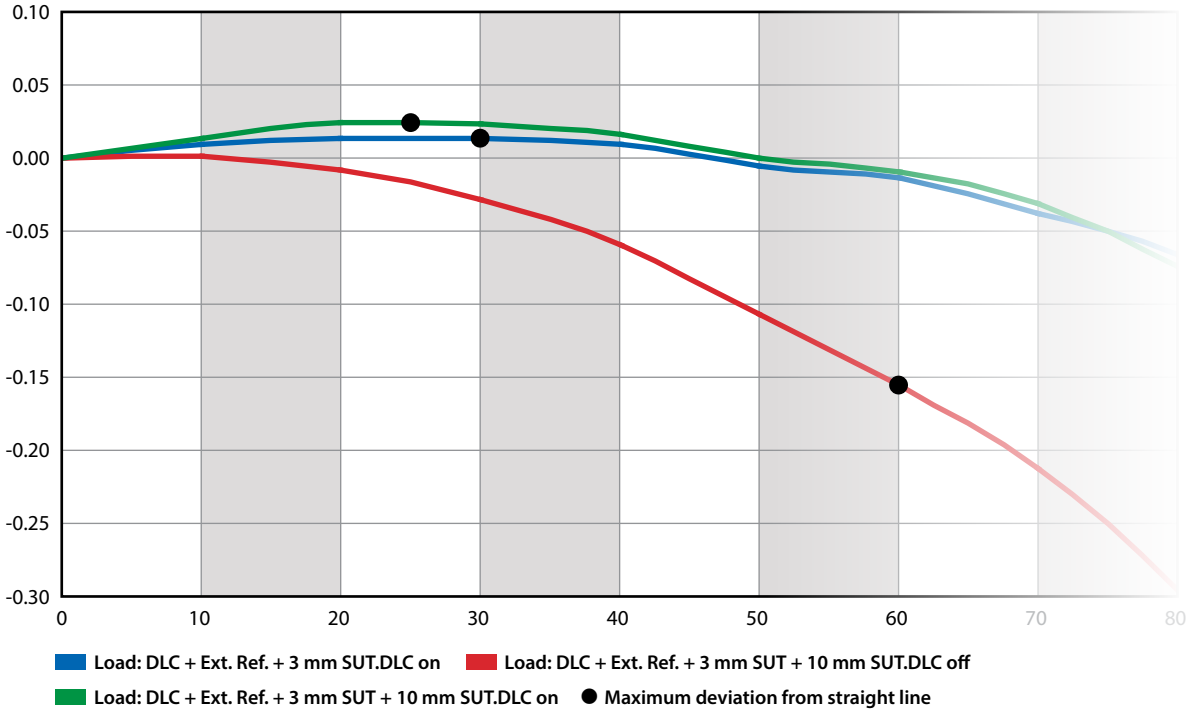
The display value of the DLC shows 0.00 (or very close to this value) when the minimum axial gradient has been achieved.

How Much Does the DLC System Improve Your Calibration Results?

The DLC system improves the calibration accuracy significantly. This may be illustrated and proven by two different test scenarios.

The first scenario shows the improvements when measuring in the insert. The graph below illustrates the temperature change in the insert as a function of the distance from the bottom. Ideally this should be a straight line with no temperature variation vertically in the insert. If so, the axial gradient would be zero. However, in reality, this is not true. To prove that the DLC functionality will improve the axial gradient, three tests have been performed. The data provided is for the lower 60 mm.

▶ RTC-156, S/N 574360-00037: Axial Homogeneity @ 155° C



The first test puts a very light load on the RTC calibrator, which should produce very little axial gradient (**blue line**). The load is a 4 mm external reference sensor and 3 mm sensor under test with the DLC sensor activated. The maximum deviation from the ideal straight line is 0.015° C.

The second test loads the RTC calibrator more heavily (**red line**). A thicker, 10 mm sensor is added to the configuration detailed in the previous test. The DLC functionality is not activated. The heavier loading of the calibrator causes a nonlinear axial gradient. The maximum deviation from the ideal straight line is 0.160° C.

The final test is carried out with exactly the same load as the second test, but with the DLC activated. The straightened gradient (**green line**) represents the much improved axial gradient. The maximum deviation from the ideal straight line has improved to just 0.025° C.

The effect of using the patent pending DLC system can be expressed in two ways:

1. A heavily loaded RTC calibrator can perform a close to ideal straight line gradient by activating the DLC functionality.
2. The maximum deviation from the ideal straight line is, in this example, improved by a factor of 6 by activating the DLC.

How Much Does the DLC System Improve Your Calibration Results? (cont.)

The second scenario shows the improvement when comparing with an ideal bath calibration. The principle of this test is to calibrate a sensor in a calibration bath and compare the result with the results of the same sensor in an RTC calibrator (with and without the DLC function).

In the following table, ideal calibration is represented by line 1. Lines 2 and 3 represent the original sensor in an RTC calibrator with the addition of a 10 mm sensor.

	Test Setup	Set (°C)	True (°C)	SUT1 (°C)	SUT1 Deviation (°C)	Deviation from bath calibration (°C)
1	Bath Calibration	155.000	154.973	154.923	-0.050	—
2	RTC-156 **DLC = off,** SUT1 + SUT2	155.000	155.000	154.974	-0.026	**0.024**
3	RTC-156 **DLC = on,** SUT1 + SUT2	155.000	155.000	154.958	-0.042	**0.008**

Example: Calibration of an OD 3mm (SUT1) and OD 10 mm (SUT2) at the same time.

The extra load on the calibrator has a significant impact on the calibration result of the 3 mm sensor when the DLC functionality is *not* activated (line 2).

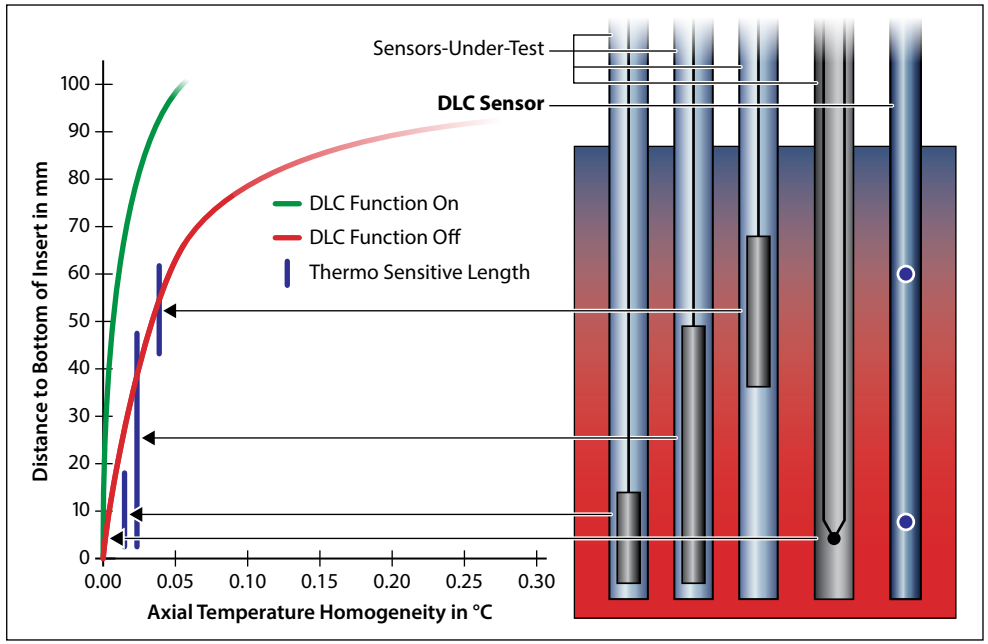
With the exact same load on the RTC calibrator, the DLC functionality is activated and the accuracy is improved (line 3).

This test shows the following effect when using the DLC:

1. Uncertainty due to thermal load is reduced by a factor of 3 when using the DLC (ratio 0.024 : 0.008 = 3)
2. The DLC provides optimum accuracy under any thermal loads.

What Are the Advantages of the Patented DLC System?

- Calibration of several sensors simultaneously.
- Calibration of large diameter sensors.
- Since no standard temperature sensors have a thermo-sensitive length beyond 60 mm, it is no longer necessary to know the length of the thermo-sensitive part of the sensor. Just plug it in!
- The DLC indicator shows that the dual-zone is active and working.
- The DLC value is very close to 0.00 whether the calibrator is loaded or not, making for a perfectly working temperature calibrator.
- Calibration value indication. The DLC indicator shows when the temperature homogeneity in the lower 60 mm part is achieved.



What Are the Important Benefits for the User?

- Saves time by calibrating more sensors simultaneously.
- Calibrating big diameter sensors without losing accuracy due to heat conduction.
- TSL (Thermo Sensitive Length) independency. Save, secure, and accurate calibration results without spending time to get sensor specifications from your supplier.
- The DLC function minimizes the influence from sensor production tolerances, like the Pt100 element being mounted in various positions in the sensor.
- The displayed DLC value indicates when the optimum temperature homogeneity is achieved, and when the load has no influence on the calibration result.
- When the DLC value is close to zero, the calibration technician knows that the calibration results are reliable.
- The DLC indicator proves that the dual-zone is active and well-functioning.
- The DLC in conjunction with the stability indicator show when the calibration value is ready (the "green-zero" rule — see page 8).

Why Does the DLC Have a Positive Impact on the Uncertainty Budget?

Our customers often want to make uncertainty budgets for their calibrations. This is usually done by entering the values from the supplier's datasheet. These values are normally rather conservative, to ensure that specifications are valid for all calibrators.

The uncertainty budget results are consequently very high. Through the DLC measurement, some of the specifications can be changed with the actual values of the instrument, thus providing a far better measuring capability of the calibrator.

▶ Uncertainty Budget for RTC Calibrator Loaded with Ø 10 mm Sensor

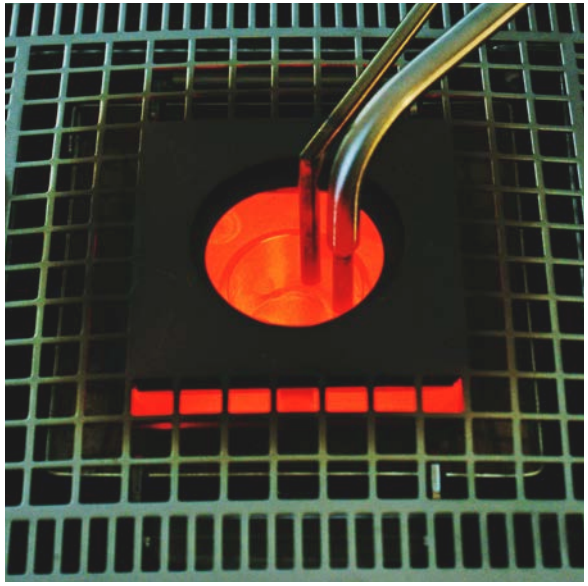
DLC Off or On	1	Temperature of Reference Thermometer	155.002			
	2	Uncertainty Reference Thermometer (k=2)		0.015	Normal	0.0075
	3	Resolution of RTC Temperature Indicator		0.001	Square	0.0003
	4	Hysteresis Effect		0.008	Square	0.0046
	5	Radial Temperature Homogeneity		0.004	Square	0.0023
	6	Loading Effect		0.004	Square	0.0023
	7	Stability in Time		0.003	Square	0.0017
DLC Off	8	Axial Temperature Homogeneity		**0.159**	Square	0.0918
			155.002		k=1	0.092
		Geometrical Sum*			k=2	**0.185**
DLC On	8	Axial Temperature Homogeneity		**0.024**	Square	0.0139
			155.002		k=1	0.017
		Geometrical Sum*			k=2	**0.034**

*** Geometrical sum: Square root of the sum of the squares.**

This comparison shows the following effect when using the DLC:

1. Uncertainty of the axial gradient has been reduced by 85% when using the DLC system.
2. The RTC calibrator is performing within specifications even while heavily loaded.
3. The total uncertainty is improved by a factor of 5 when using the DLC function.
   Improvement factor = ratio 0.185 : 0.034 > 5

The advantage of the DLC system is illustrated by comparing of two uncertainty budgets.



How Can the Calibration Technician Tell When the Calibrator is Ready?

The RTC calibrator shows and proves when the optimum gradient and stabilization has been achieved: the "green-zero" rule. No other calibrators worldwide are able to provide this essential status information.

The "green-zero" rule as shown on a type B of the RTC calibrator series.

What Are the Most Frequently Asked Questions in Connection with the DLC?

- Does the DLC sensor have any negative impact on the calibration accuracy?
  Since the diameter of the DLC sensor is only 3 mm, it does not impact the measurements.
- What is the significance of the sign in the DLC display value?
  A positive display value of the DLC means that the top of the 60 mm measuring zone is hotter than the bottom, and vice versa.
- Can the DLC system also be used with short sensors and clamp sensors?
  No, the DLC System can only be used with a fully immersed sensor-under-test.

What Are the Major Conclusions Related to the DLC System?

1. The RTC calibrator with the DLC system is the only dry-block in the world that fully compensates for the actual load.
2. The deviation from an ideal bath calibration is improved by a factor of 3 with the DLC.
3. With reference to a load test with a 10 mm load sensor, the axial gradient over a 60 mm length is improved by a factor of 6 by activating the DLC system.
4. All temperature sensors can be calibrated without first spending costly time on investigating sensor details such as Thermo Sensitive Lengths, production tolerances, etc.
5. The DLC display supports your effort to make a more qualified and realistic uncertainty budget.
6. Typically, you just have to trust datasheet specifications. With the DLC system, you have the first temperature calibrator with a display that shows and proves its own datasheet specifications.

Calibrators with DLC

RTC-156

Temperature range from -30 to 155° C (-22 to 311° F)
General purpose, light-weight, and high performance dry-block.

RTC-157

Temperature range from -45 to 155° C (-49 to 311° F)
General purpose, light-weight, and high performance dry-block with superior low temperature performance.

RTC-158

Temperature range from -22 to 155° C (-8 to 311° F)
Combined liquid bath and dry-block with a large diameter insert. Designed for calibration of odd sizes or shapes of sensors, or when calibrating multiple sensors at a time.

RTC-159

Temperature range from -100 to 155° C (-148 to 311° F)
The most versatile temperature calibrator available with a temperature range that makes it especially ideal for use in the health care, medical, pharmaceutical, biotechnology, and food industries.

RTC-250

Temperature range from 28 to 250° C (82 to 482° F)
Combined liquid bath and dry-block with a large diameter insert. Designed for calibration of odd sizes or shapes of sensors, or when calibrating multiple sensors at a time.

RTC-700

Temperature range from 33 to 700° C (91 to 1292° F)
A unique combination of speed and accuracy at very high temperatures, based on our new patent pending heating block.

USA, Florida
Tel +1 (800) 527 9999
cal.info@ametek.com

USA, California*
Tel +1 (800) 444 1850
crystal@ametek.com

India
Tel +91 22 2836 4750
jofra@ametek.com

Singapore
Tel +65 6484 2388
jofra@ametek.com

China, Shanghai
Tel +86 21 5868 5111
jofra.sales@ametek.com.cn

China, Beijing
Tel +86 10 8526 2111
jofra.sales@ametek.com.cn

United Kingdom
Tel +44 (0) 1243 833 302
caluk.sales@ametek.com

France
Tel +33 (0) 30 68 89 40
general.lloyd-instruments@ametek.fr

Germany
Tel +49 (0) 2159 9136 510
info.mct-de@ametek.de

Denmark*
Tel +45 4816 8000
jofra@ametek.com

TN–DLC Issue 1707

*ISO 17025 accredited calibration lab.

JOFRA® calibration

AMETEK®
SENSORS, TEST & CALIBRATION