

C-THERM

# DILATOMETRY

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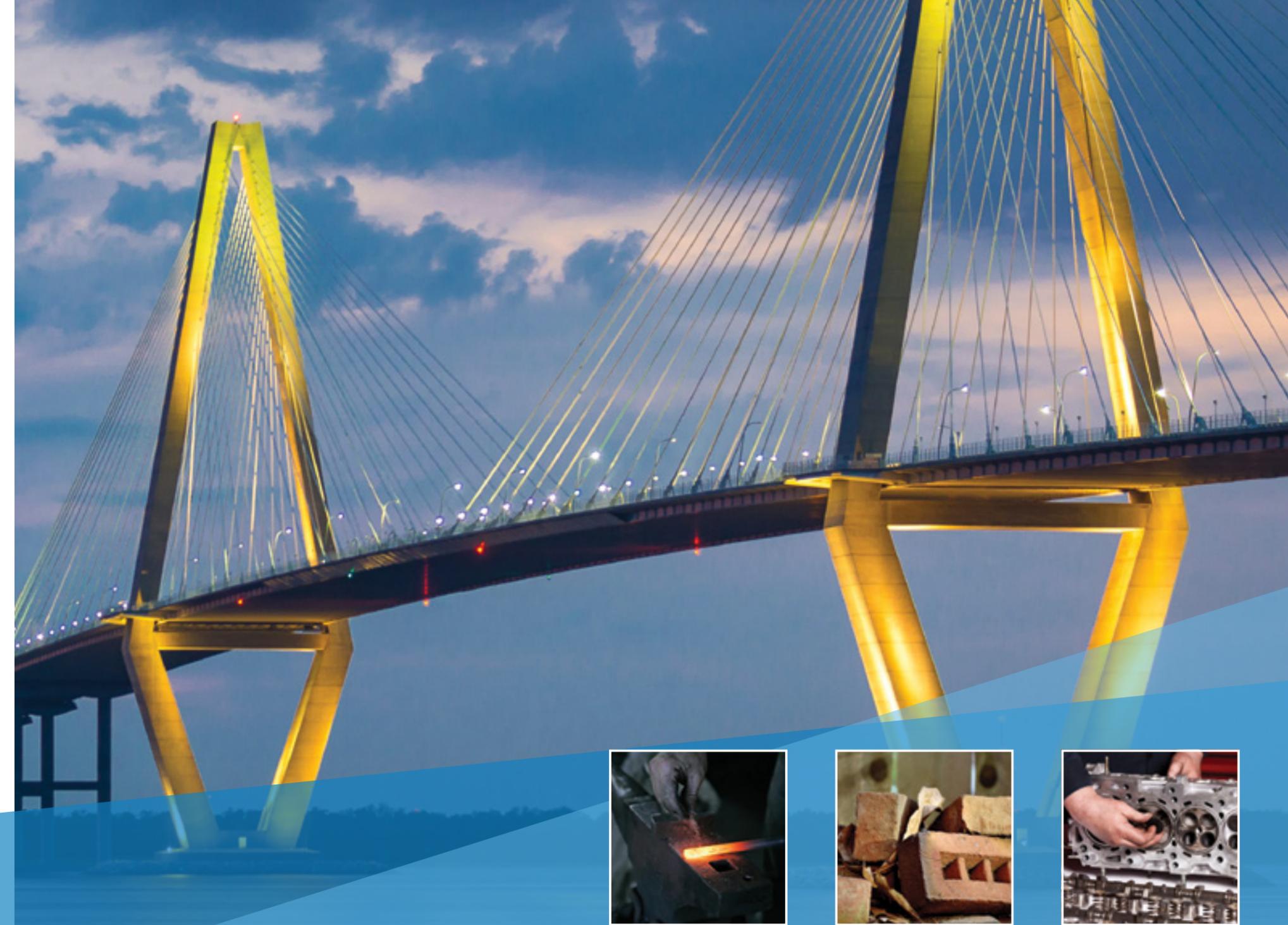
Pushrod dilatometry is a method for characterizing dimensional changes of a material as a function of temperature. The measurement may be performed across a temperature range (e.g. from 800° to 1,600°C), or a specific controlled temperature program to mimic industrial processes, firing regimes, or a material's operating environment. The coefficient of thermal expansion ( $\alpha$ ) is defined as the degree of expansion ( $\Delta L$ ) divided by the change in temperature ( $\Delta T$ ).

$$\alpha = \frac{1}{L_0} \left( \frac{\Delta L}{\Delta T} \right)$$

$\alpha$	Coefficient of expansion
$L_0$	Initial sample length
$\Delta T$	Change in temperature
$\Delta L$	Change in length

A precise understanding of thermal expansion behaviour provides crucial insight into firing processes, the influence of additives, reaction kinetics and other important aspects of how materials respond to environmental changes. Typical applications include: the determination of the coefficient of thermal expansion, annealing studies, determination of glass transition point, softening point, densification, kinetics and sintering studies.

C-Therm dilatometers offer high resolution and stability across a broad measurement range. With unparalleled ease-of-use, high adaptability, and modular design, C-Therm dilatometers offer researchers a robust cost-effective solution to their characterization needs.



# C-THERM DiL

MODULAR SINGLE OR DUAL SAMPLE DILATOMETER  
UP TO 1600°C

C-Therm dilatometers provide a high-precision measurement for characterizing the dimensional changes of a material as a function of temperature.

Conforms to all major standard test methods for dilatometry, including **ASTM E228**.



C-THERM

TEMPERATURE RANGE  
Room Temperature to 1600°C

TEMPERATURE RESOLUTION  
0.1°C

MAX DISPLACEMENT  
4 mm

ΔI RESOLUTION  
1.25 nm/digit

ATMOSPHERE  
Air, Vacuum, Inert Gas, Reducing, Oxidizing, Static & Dynamic

SAMPLE DIMENSIONS  
10 to 50 mm long  
4-12 mm φ

SAMPLE HOLDER  
Fused Silica, Alumina

CONFIGURATIONS  
Single or Dual LVDT Measurement Channels  
1200°C or 1600°C Modular Furnaces

HEATING ELEMENT  
Kanthal Wire (FeCrAl), SiC

RATE OF INCREASE (°C)  
Up to 50°C/min

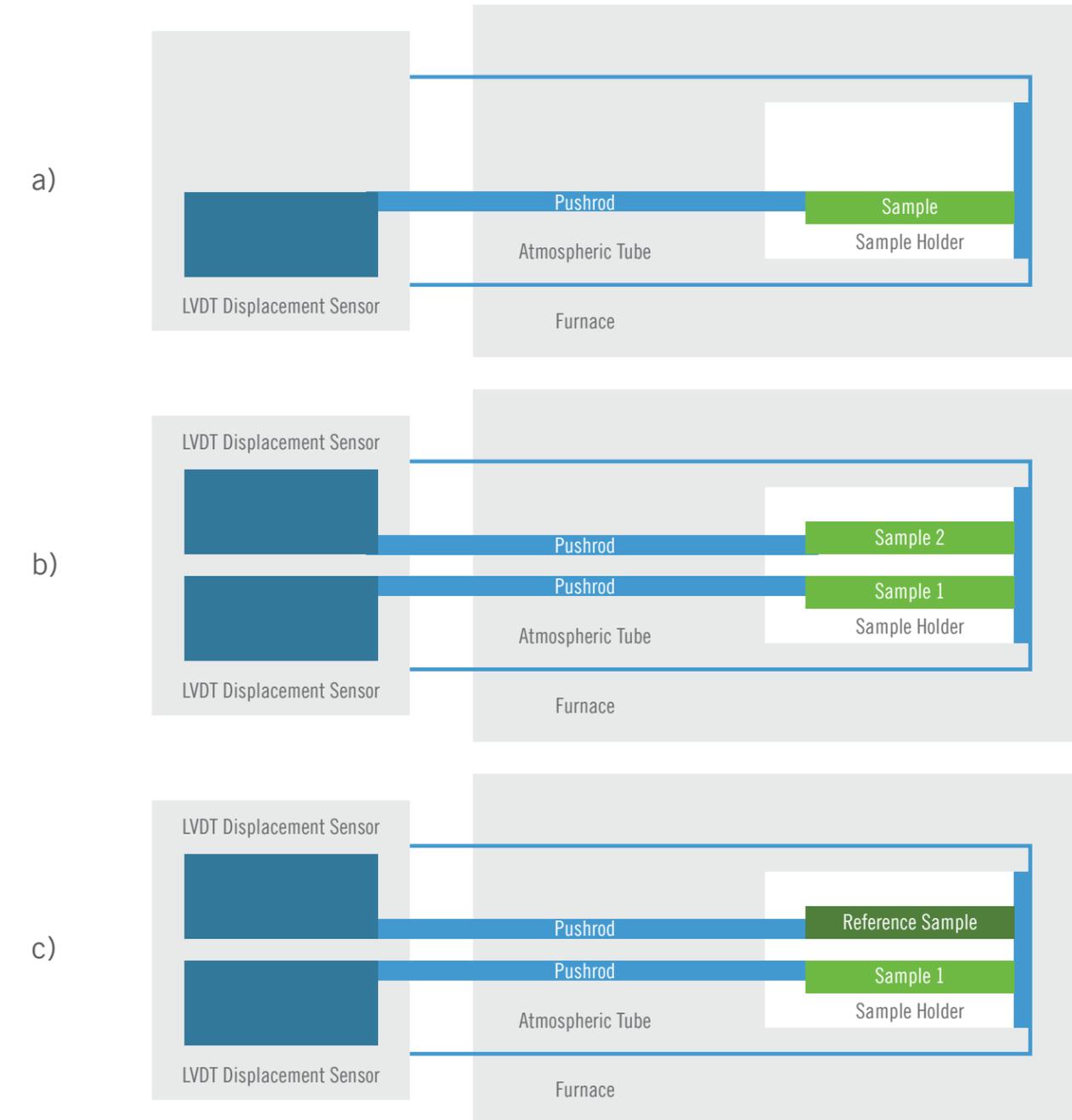
# PRINCIPLE OF OPERATION

A sample is placed inside a retractable, tubular furnace. A spring-loaded pushrod is positioned against the sample. The opposite end of the pushrod is connected to a linear variable displacement transducer (LVDT). The dimensional change of the sample resulting from the controlled temperature program is measured as the pushrod physically transmits the length change to the LVDT. The displacement is recorded in relation to the temperature recorded with a thermocouple located next to the sample. A calibration or correction curve is applied in compensating for the expansion of the sample holder and pushrod.

## SINGLE, DUAL OR DIFFERENTIAL

C-Therm dilatometers can be configured as a single or dual sample configuration and also run as a differential measurement.

- a) The single sample configuration offers users an economical, robust solution.
- b) With the dual sample arrangement, the system's capacity is doubled for higher-volume sample throughput.
- c) In replacing the second sample with a reference standard the system offers calibration-corrected measurement in one run. The differential arrangement is most appropriate when time is at a premium and the stability of long-term drift is of greater concern.

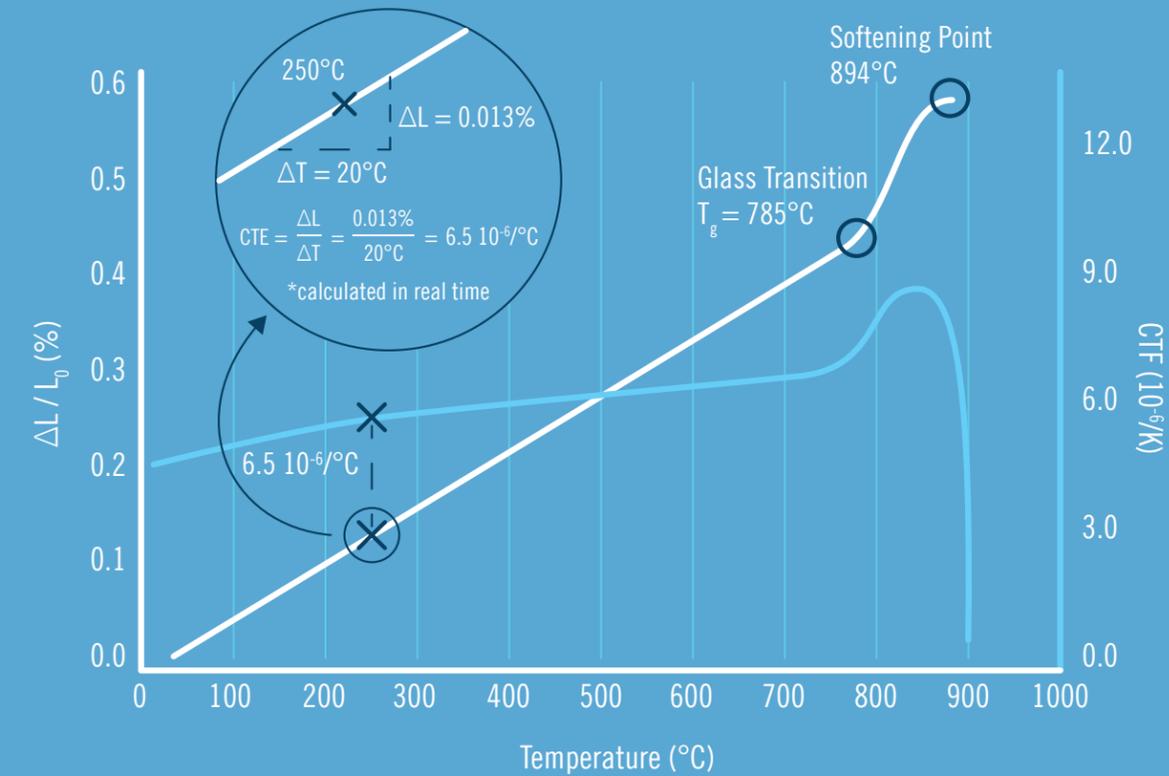
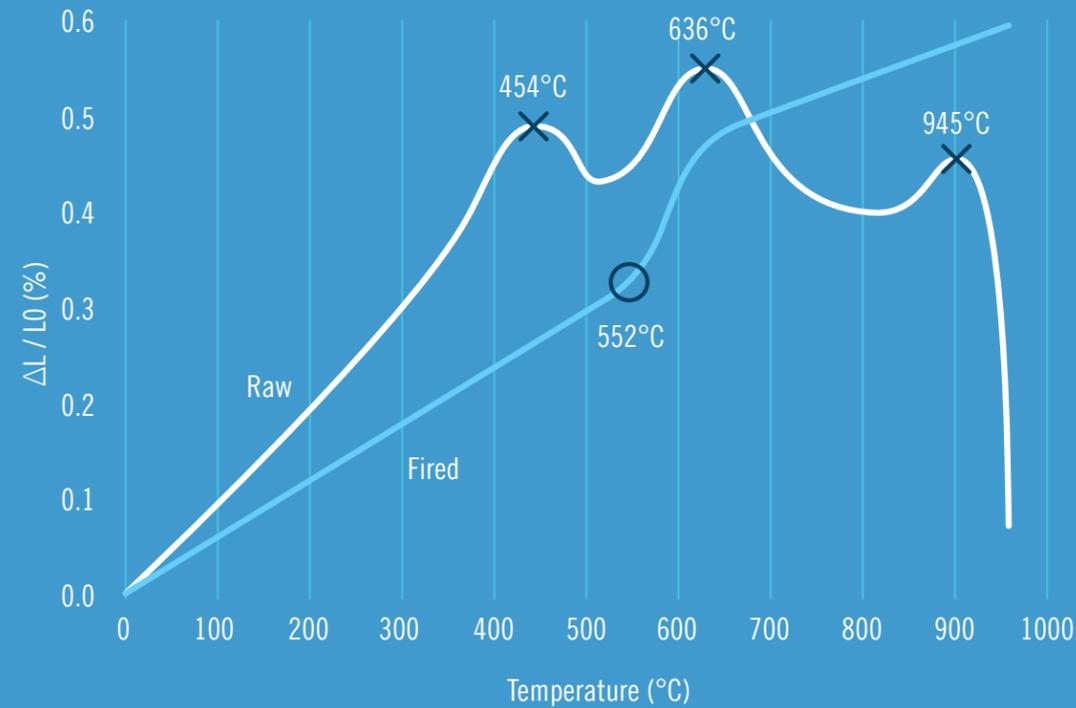


# APPLICATIONS

## COMPARING RAW VS. FIRED CERAMIC

Comparison of a ceramic's thermal expansion before and after firing gives insight into its behavior across a range of temperatures. This data is valuable in refining the firing process, and understanding how a material performs in high-temperature applications.

Right: The unfired raw ceramic (white) undergoes a variety of complex irreversible changes (X) such as diffusion, water expulsion, chemical reaction and sintering, as well as reversible overall thermal expansion. In contrast, the fired ceramic (blue) exhibits only thermal expansion and a phase transition (O) at 552°C, demonstrating the overall effects of firing and the resulting fired ceramics thermal expansion behavior.



## UNDERSTANDING CERAMIC GLAZES

Glazing is a critical process in the final production of ceramics, from capacitors to cookware. To ensure a properly glazed ceramic, the Coefficient of Thermal Expansion (CTE) must be considered for both the glaze and the base ceramic. Ideally, the glazing exhibits a slightly lower CTE than the ceramic to facilitate a tight lamination. A larger glaze CTE can result in cracking and a weaker finished product, due to a CTE mismatch between the glaze and substrate.

Left: A ceramic glaze (white) was heated through its glass transition point ( $T_g$ ) at  $785^\circ\text{C}$  and to its softening point ( $894^\circ\text{C}$ ). The resulting CTE (blue) is calculated and displayed in real-time via the right y-axis.

# ACQUISITION SOFTWARE

The hallmark of any C-Therm instrument is an easy, intuitive user-experience and this is especially true for C-Therm's dilatometers. The user interface is simple, yet powerful. Quick-select heating profiles allow users to customize testing parameters and easily repeat tests - all from the same screen!



Easy temperature profile generation



Selectable / switchable axis



Zoom area select feature



Snapshot function for easy sharing of graphs



Export to Excel™



## DATA PROCESSING SOFTWARE



C-Therm's dilatometer acquisition software can be additionally upgraded with Calisto from C-Therm's partners at Setaram Instrumentation. Calisto is an intuitive and powerful analysis software module with significant mathematical features including; glass transition determination, calculation of coefficients of thermal expansion (alpha, true alpha, average alpha), derivative, smoothing, temperature correction, data spike removal, and many more specialized functions.

# THERMAL CONDUCTIVITY

ADD  $k$ -MODULE

C-Therm's dilatometer leverages the same advanced controller system as our TCi Thermal Conductivity Analyzer. This offers users the benefit of easily adding the thermal conductivity module to their dilatometer at minimal cost in capitalizing on savings of up to 42%!

The C-Therm TCi Thermal Conductivity Analyzer offers users the fastest, easiest way to measure thermal conductivity. Test solids, liquids, powders or pastes in seconds across a broad range of environmental conditions.

UP TO  
**42%**

SAVINGS WITH  
COMBINED SYSTEM



**C-THERM**

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