



A dilatometer is normally used to measure the expansion or shrinkage of solids with changing temperatures.

LINSEIS Incorporated has been manufacturing dilatometers for more than 40 years. Dilatometers are used to determine the expansion coefficients of various solids. Often a dilatometer is also used to establish a ZTU diagram of metals and alloys. New applications include the determination of the sintering process of ceramics, metals, or powdered metal.

The principle of the LINSEIS dilatometer consists of measuring the ΔL value of a sample during a temperature change. The temperature change is achieved by heating or cooling through a programmed cycle. An absolute dilatometer measures the expansion of

The basic dilatometer unit consists of a frame holding the expansion sensor, the sample holder, and the moving slide for the furnace. There are many features available to customize the dilatometer to the application and the material. There are a number of different furnaces available covering temperature ranges between -150°C and $+2300^{\circ}\text{C}$.

There are horizontal as well as vertical dilatometers. All economy models are available in horizontal versions only. If the temperature range is above 1550°C a vertical model is necessary to support Al_2O_3 measuring systems. Therefore, dilatometers for 1750°C with Al_2O_3 measuring system are only available in a vertical model. Graphite measuring systems are available for 2000°C and 2300°C . These systems operate in an inert atmosphere or vacuum. All dilatometers, except the economy versions are capable of operating in vacuum or dynamic atmospheres.

the sample relative to the sample holder. A dual pushrod dilatometer measures either two samples or the difference between a sample and a reference material.

Recently, dilatometers have been used for quality control purposes in the incoming material inspection or the final production. Interesting examples include the manufacturing of catalytic converters and heat shields for the aerospace industry.



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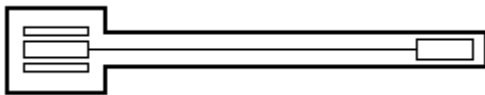
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Measuring systems and thermocouples for dilatometers

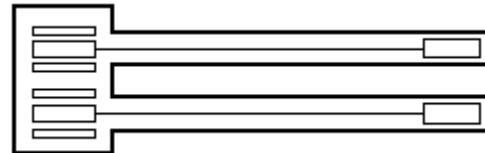
The measuring system of a dilatometer consists of a sample holder and a push rod. The later one is used to transfer the expansion of the material out of the heated zone to the LVDT. The thermocouple that measures the temperature directly over or in a hole of the sample measures the actual sample temperature.

The available measuring systems are as follows:

range	material	sample	TC Type
-150°C - 400°C	quartz	7mm	K
20°C - 1100°C	quartz	14mm	K
20°C - 1550°C	Al ₂ O ₃	14mm	S
20°C - 1750°C	Al ₂ O ₃	14mm	B
20°C - 2300°C	graphite	14mm	C



single pushrod sample holder



dual pushrod sample holder



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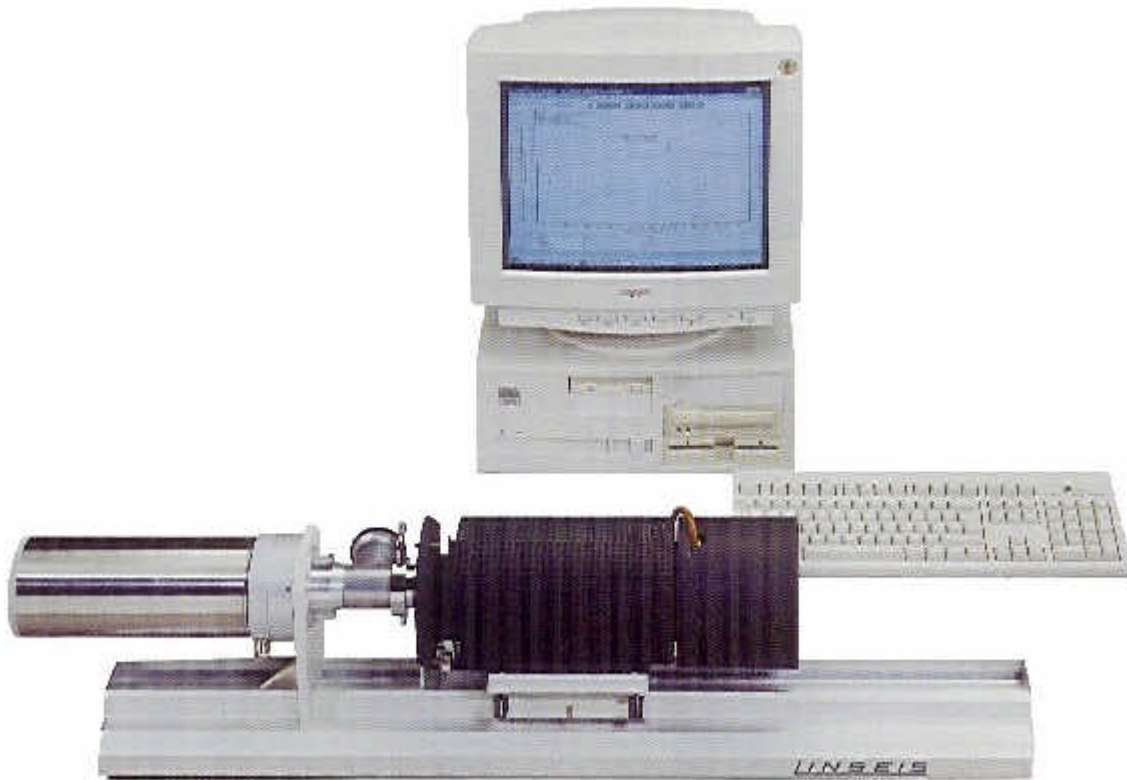
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Horizontal Dilatometer with single pushrod

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L75 series dilatometers are equipped with an option to run under normal vacuum, or a controlled atmosphere. All measuring systems are manufactured to the highest standards and with LVDT's having the best precision and accuracy.

A complete dilatometer system consists of dilatometer basic unit, measuring system complete with: sample holder, pushrod, protection tube, furnace, Pentium computer with ink jet printer, Linseis Windows® software with control, data acquisition, and evaluation packages included.

There are various options available for all dilatometers Examples: quenching option (for fast cooling rates) automatic sample length measurement, variable sample pressure control, glaze testing with steeger equipment, gas control systems, vacuum stand.

Single push rod dilatometers are manufactured for temperature ranges between -150°C and 2300°C The L76 economy dilatometers have no vacuum or gas flow options. They are a very useful tool for quality control and educational applications.

The L76 economy models available are:

L76/1000 horizontal dilatometer	20 - 1000°C
L76/1250 horizontal dilatometer	20 - 1250°C

L75 series dilatometers are built to suit the most demanding industrial or educational applications in research and development laboratories.

The L75 models available are:

L75/1000 horizontal dilatometer	20 - 1000°C
L75/1250 horizontal dilatometer	20 - 1250°C
L75/1550 horizontal/vertical	20 - 1550°C
L75/1750 vertical dilatometer	20 - 1750°C
L75/2000 vertical dilatometer	20 - 2000°C
L75/2300 vertical dilatometer	20 - 2300°C

Technical data for dilatometers: (typical for quartz glass systems)

resolution:	+/- 14nm
reproducibility:	+/- 150nm
measuring range:	+/- 2500µm

sample diameter: 7/14 mm
sample length: 25mm



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Dual Pushrod Dilatometer DMA/TMA

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Dual pushrod dilatometers can perform 2 absolute measurements or 1 differential measurement between 2 samples. Dual pushrod dilatometers are available in vertical models only.

The L75D models available are:

L75D/1000 vertical dilatometer,
temperature range 20 - 1000°C

L75D/1250 vertical dilatometer,
temperature range 20 - 1250°C

L75D/ 1 550 vertical dilatometer,
temperature range 20 - 1550°C

L75D/ 1 750 vertical dilatometer,
temperature range 20 - 1750°C

L77/1000 DMA vertical
temperature range 20 - 1550°C



Reference Materials:

Instrument calibration insures the best test results of material expansion or shrinkage. (see DIN51045). Calibration is performed using one of the following reference materials depending on temperature range: platinum, sapphire tungsten, quartz, fused silica, or copper. Test conditions must be duplicated during the calibration procedure including heating rate, sample holder material, furnace, gas flow, and atmosphere conditions.

Dilatometers with a temperature range up to 1550°C are available as table- top units. The L75/1750 and L75/2300 dilatometers are available with floor mounted cabinets. All vertical dual pushrod dilatometers feature a motor driven furnace lift. All dilatometers have auto-zeroing and automatic sample length measurement included. The vertical models eliminate any friction between the sample and the measuring system. Optionally an automatic pressure control is available. The dual pushrod operation, when used for higher temperatures with Al_2O_3 measuring system, is the ideal way to achieve the highest possible resolution of a dilatometer. The DMA L77 is for dynamic mechanical analysis, measuring penetration, dilatation and E-modulus.



calibration standard	temperature range	(CTE) 10E-1 (K - 1)
fused silica	-193°C - 1407°C	4
quartz	-193°C - 1727°C	0,5
copper	-253°C - 1527°C	17
platinum	-120°C - 1620°C	10
sapphire	-120°C - 1727°C	9,5
tungsten	-196°C - 1527°C	4

The difference between the theoretical and the measured expansion values as a correction function and can be displayed graphically. Most reference materials are available with a calibration certificate.



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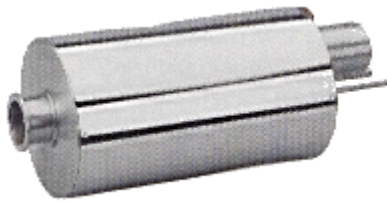
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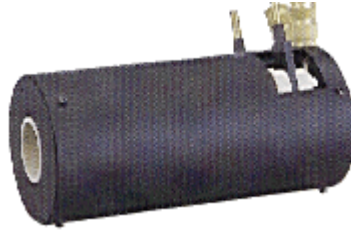
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Dilatometer Furnace Programs

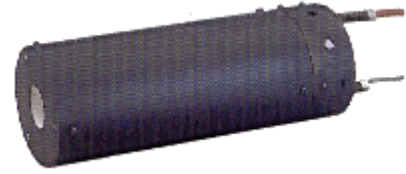
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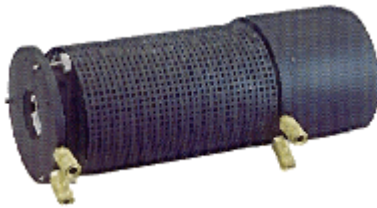
temperature range: -150°C - 500°C



temperature range: 20°C - 1000°C



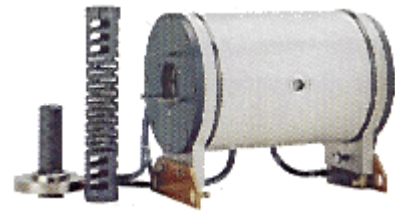
temperature range: 20°C - 1250°C



temperature range: 20°C - 1550°C



temperature range: 20°C - 1750°C



temperature range: 20°C - 2300°C

Horizontal

Temperature	Type	Element	Temp. Variation	Atmosphere	Coolant	TC type
20°C-1000°C	L75/220	Kanthal wire	+/- 1,5°C	air	water	K
20°C-1250°C	L75/230	kanthal wire	+/- 1,5°C	air	water	S
20°C-1550°C	L75/240	SiC	+/- 2°C	air	water	S
20°C-2300°C	L75/260	graphite	+/- 3°C	N2/vacuum	water	pyrometer

Vertical

-150°C-500°C	L75/264	thermo coax	+/- 2°C	air	LN2	K
20°C-1000°C	L75/220	kanthal wire	+/- 1,5°C	air	water	K
20°C-1250°C	L75/230	kanthal wire	+/- 1,5°C	air	water	S
20°C-1550°C	L75/240	SiC	+/- 3°C	air	water	S
20°C-1750°C	L75/250	pyrox	+/- 3°C	air	water	EL18
20°C-2300°C	L75/260	graphite	+/- 3°C	N2/vacuum	water	pyrometer



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All LINSEIS Thermal Analysis Instruments are controlled through sophisticated Windows® software. The complete program consists of three sections: temperature control, data acquisition, and data evaluation. Essential sample information is entered in the data acquisition section.

Data Acquisition section

Data Acquisition Setup - Double Sample

Operator: Atmosphere:

Laboratory: Flow Rate: [l/h]

Piston Material: (Dropdown menu showing: Quartz, Alumina, Graphite, Quartz)

Dilatometer 1	Dilatometer 2
Sample File: <input type="text" value="SAMPLE-1.IPR"/>	Sample File: <input type="text" value="SAMPLE-2.IPR"/>
Zero File: <input type="text" value="ZERO-10L.INL"/>	Zero File: <input type="text" value="ZERO-10R.INL"/>
Sample Name: <input type="text" value="Test 1"/>	Sample Name: <input type="text" value="Test 2"/>
Comment: <input type="text" value="DIL measurement"/>	Comment: <input type="text" value="DIL measurement"/>
Sample Length: <input type="text" value="10.00"/> [mm]	Sample Length: <input type="text" value="10.00"/> [mm]
Range: <input type="text" value="250"/> [µm]	Range: <input type="text" value="250"/> [µm]

Sampling Interval: [sec] Duration: [min]

Max. Temp.: [°C]

Picture 1: menu for the documentation set-up

Essential data for each sample test includes; operator, laboratory, atmosphere, gas flow, material, sample file name, zero file name, comments, sample length, measuring range, max. temperature, duration of run, sampling frequency, heating and cooling rates, number of cycles.

All menus are easily understood and intuitive. The software is quickly mastered with minimal training needed.

```
LINSEIS Dilatometer Evaluation Protocol

Common data:
-----
Date/Time: 11/14/99 13:38:42 Sample: Platinum 10.00 mm
Operator: Pog Reference: ----- 0.00 mm
```

Laboratory: LINSEIS	Atmosphere: Air	0.00 l/h		
Comment: Calibration	Zero: Null-10	Piston: Quartz		

Controller parameters:				

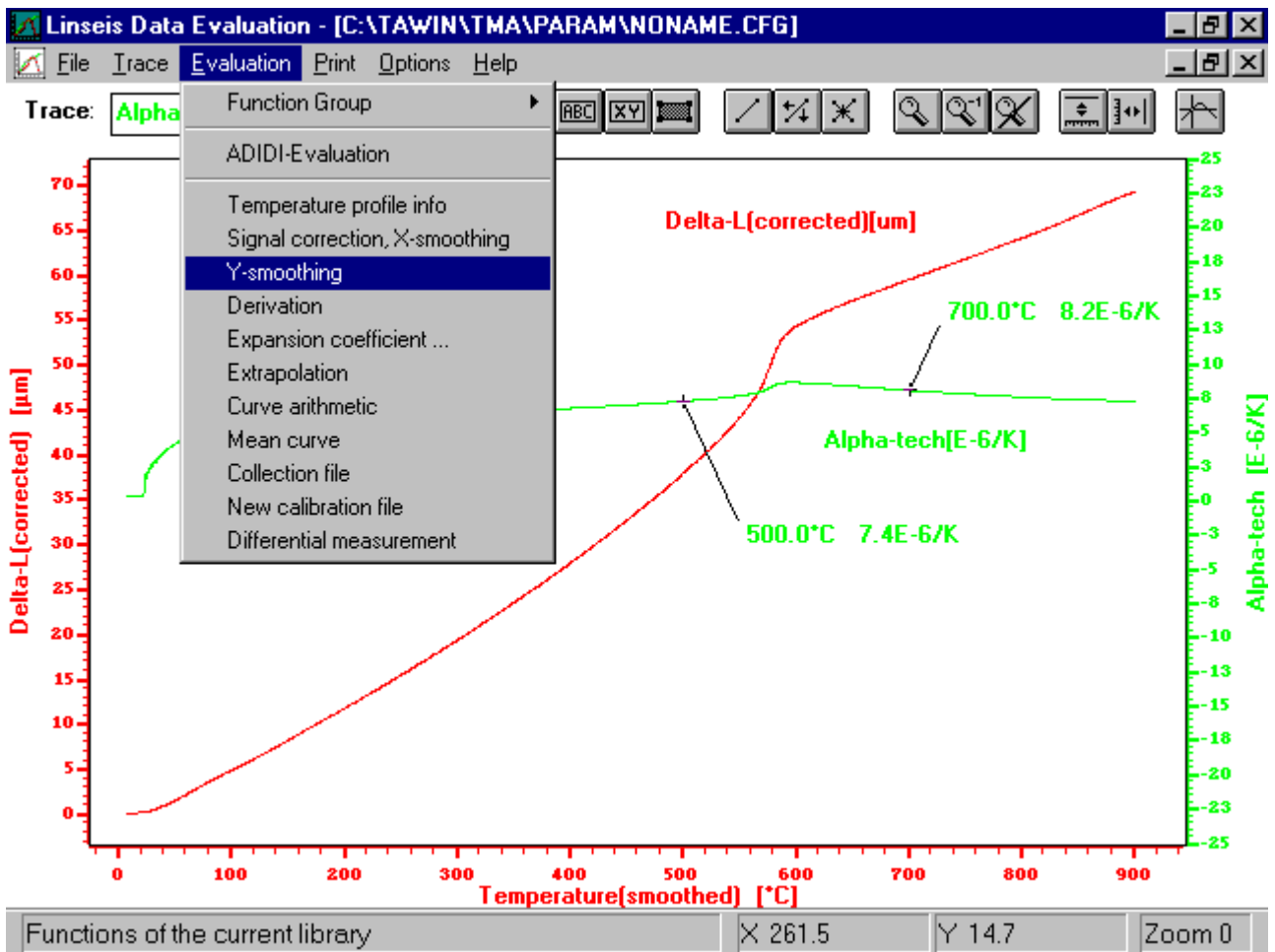
Segment	Heating [K/min]	End temperature [°C]	Dwell time[min]	
-----	-----	-----	-----	
1	10.0	830.0	0.0	
2	30.0	500.0	0.0	

Table of data and coefficients:				
Reference temperature for AKt: 20°C				
Reference temperature for AKp: 20°C				

T [°C]	dL [µm]	AKt[E-6/K]	AKp[E-6/K]	dL/L0 [%]
-----	-----	-----	-----	-----
100.0	6.94	8.68	9.66	0.069
200.0	16.26	9.03	10.82	0.163
300.0	25.85	9.23	11.12	0.259
400.0	35.49	9.34	11.40	0.355
500.0	45.21	9.42	11.62	0.452
600.0	55.78	9.62	11.98	0.558
700.0	66.33	9.75	12.34	0.663
800.0	77.24	9.90	12.75	0.772

Picture 2: results of a print-out

Evaluation section



Picture 3: the evaluation menu

The evaluation is part of the complete windows software, It features a number of functions enabling a full evaluation of all types of data. All evaluation and data collection can be performed simultaneously. Data can be corrected using zero and calibration correction. Data evaluations include: absolute length change, relative length change, and coefficient of thermal expansion. A mean curve with statistical analysis can be performed on multiple curves. Graphical displays can be printed on all windows compatible printers or plotters.

Data can be displayed and printed in a table format. The software also includes an ASCII export feature.



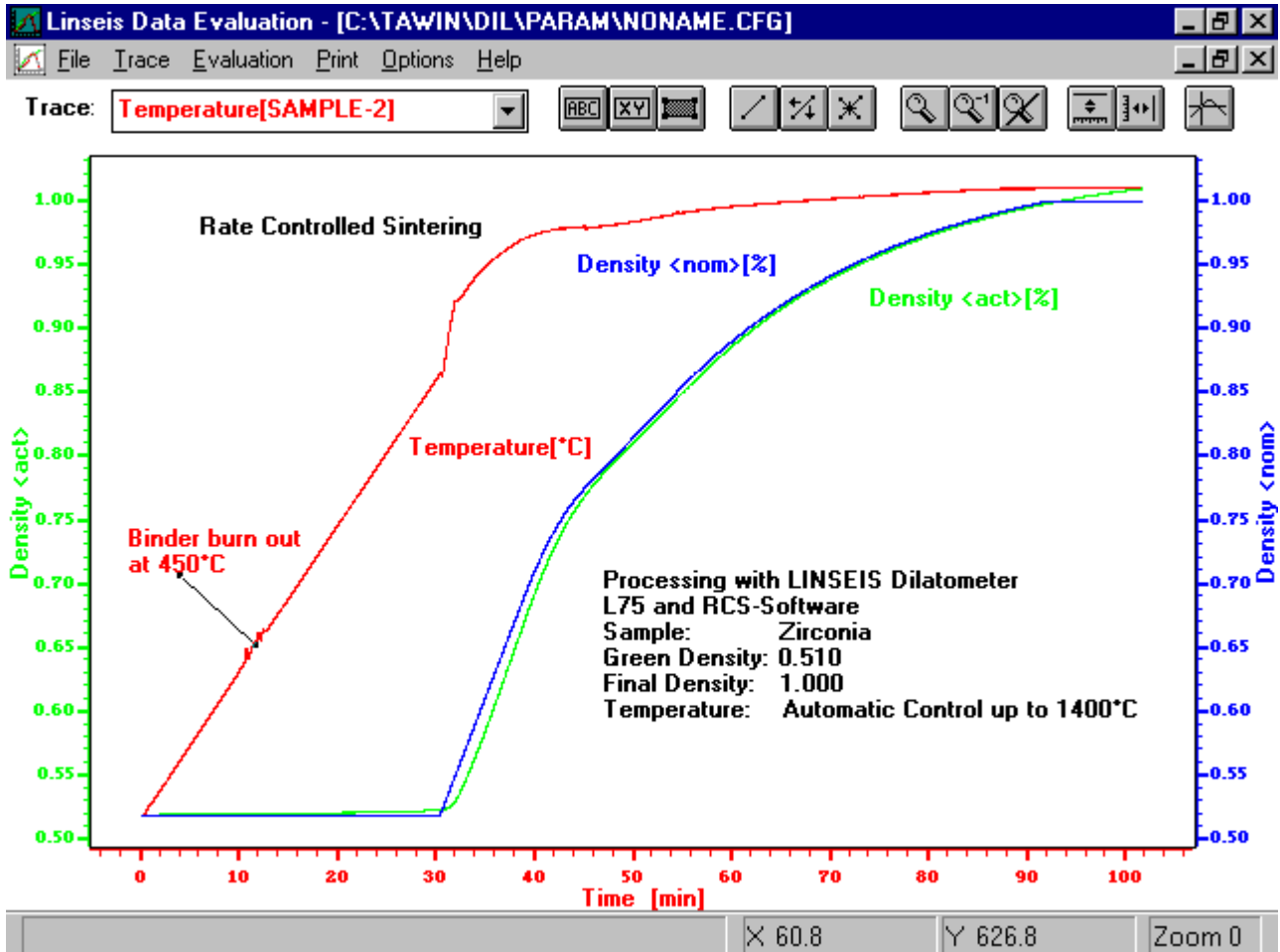
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Ceramics industry / Powder metallurgy

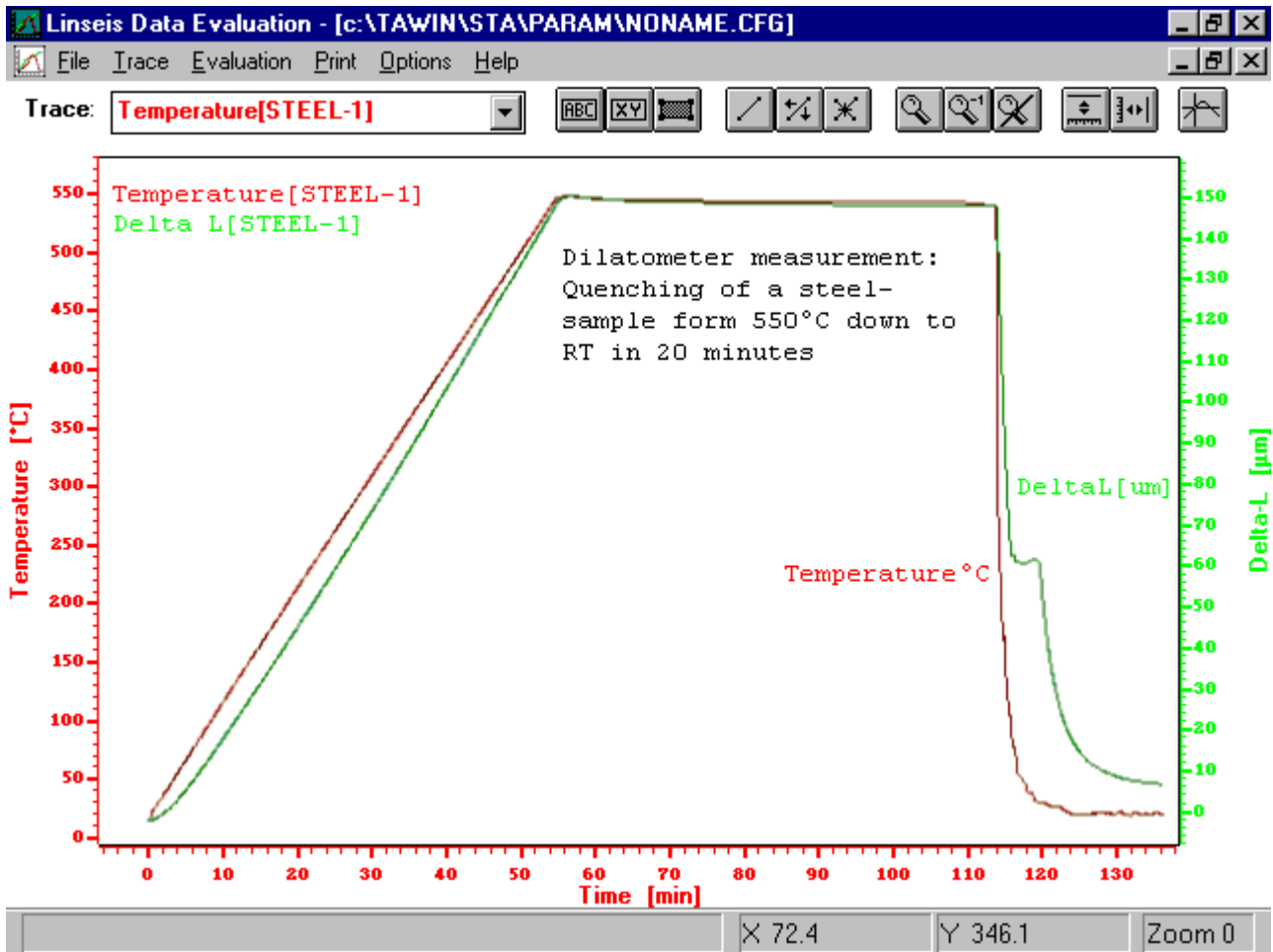


Pincture 4: rate controlled sintering

In production processes of high-tech ceramics (Al_2O_3) a simulation of sinter process's is of special interest. When using the optional software package RCS (rate controlled sintering) it is possible to program controlled sintering in the dilatometer as per the PALMOUR III theory.

Picture 4 shows the sintering process of ZrO_2 . Here the final density of 100 % is achieved. The initial heating rate decrease as the final density is reached.

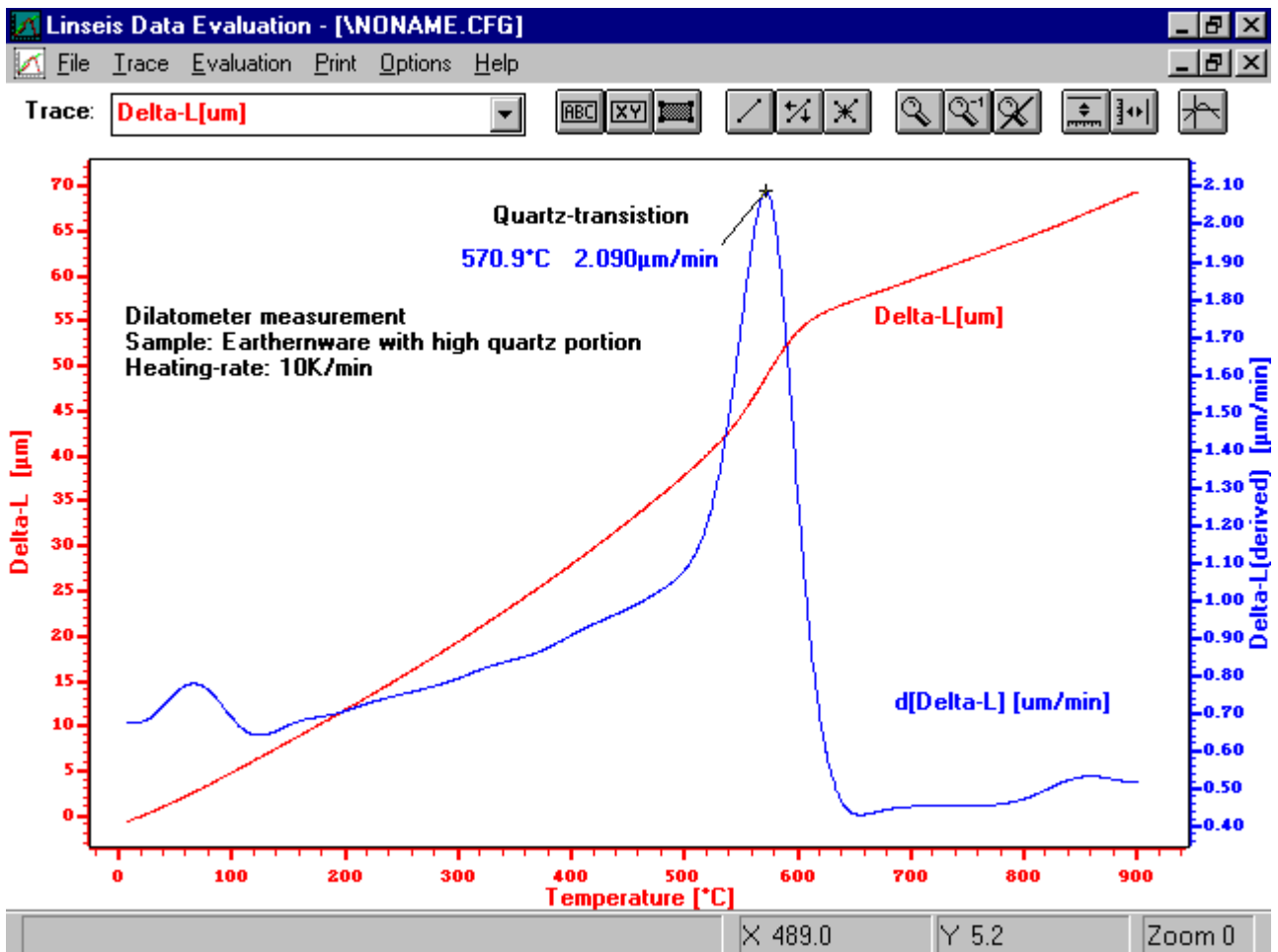
Steel industry



Picture 5: dilatometer with quenching system

Picture 5 shows a run with a steel sample that was cooled quickly with a quenching system from 550°C to room temperature over 20 minutes. At about 220°C a subtle phase change can be seen. This kind of measurement is used to draw ZTU diagrams.

Porcelain and stoneware industry



Picture 6: Quartz Crystal Change on a stoneware sample

Picture 6 shows a measurement of a clay sample with a dilatometer. This sample shows a subtle change of expansion at 570°C which comes from a alpha/beta change of the quartz crystal structure. This type of dilatometer measurement is important for the quality control in the porcelain and stoneware industry. This method will quickly determine the quality of raw materials used for the production of whitewares.



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