LINSEIS

pushing boundaries

DIL L78 Q
DIL L78 Q/D
DIL L78 Q/D/T

Thermo-pyhsical testing

Quenching & Deformation

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Since 1957 LINSEIS Corporation has been delivering outstanding service, know-how and leading innovative products in the field of thermal analysis and thermo-physical properties.

Customer satisfaction, innovation, flexibility, and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermoanalytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials, and environmental analytics. In addition, thermophysical properties of solids, liquids, and melts can be analyzed.

Rooted in a strong family tradition, LINSEIS is proudly steered into its third generation, maintaining its core values and commitment to excellence, which have been passed down through the family leadership. This generational continuity strengthens our dedication to innovation and quality, embodying the essence of a true family-run business.

LINSEIS provides technological leadership. We develop and manufacture thermoanalytic and thermophysical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal analysis equipment.

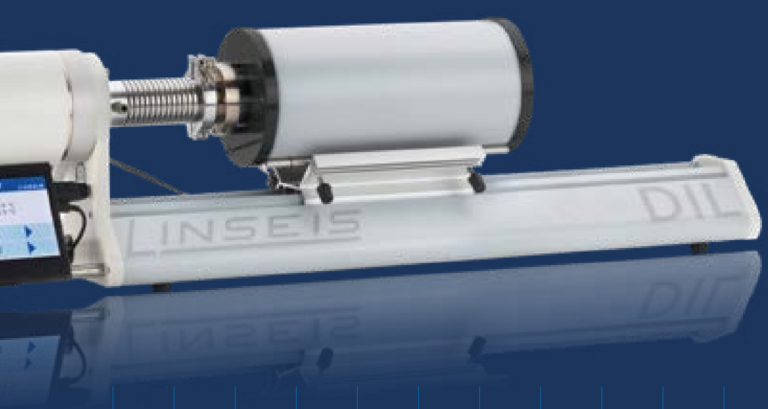
The development of thermoanalytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

CLAUS LINSEIS
CEO DIPL. PHYS.

To strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is to constantly develop new technologies to enable continued discovery in Science.

Engineering & Innovation



Thermal **physical testing**

Many metals behave like elastic objects over a certain temperature range. This range varies for different metals and is influenced by factors such as mechanical properties, atmospheric exposure (corrosion), grain size, heat treatment and working temperature.

Materials Testing Applications

- Hot/Warm Tensile Testing
- Hot Compression Testing
- Stress vs. Strain Curves
- Thermal Cycling/Heat Treatment
- Dilatometry/Phase Transformation
- Stress Relaxation Studies
- Creep/Stress Rupture
- Quench Dilatometry
- Deformation Dilatometry

Process simulation capabilities

- Hot Rolling
- Forging
- Extrusion
- Heat Treatment
- Quenching

High value metals must be extremely reliable and perform consistently under a variety of harsh and hostile conditions. It is necessary for our customers to be able to reliably analyze the properties of different metals. The results of these tests are then applied to the various environments in which the metals will be used. In this way, the manufacturing process can be optimized to produce a durable material.

Quenching and Deformation in Metallurgy

Quenching is the rapid cooling of a heated materital in a quenching medium (in our chase gas) to achieve. In metallurgy, quenching is one of the critical steps in the heat treatment of a metal and is typically used to harden the final product, e.g. steel.

DIL L78 Q (Quenching)

TTT- CCT- CHT - Diagram

There are three main types of transformation diagram that are useful in selecting the optimum steel and processing route to achieve a given set of properties. These are Time Temperature Transformation (TTT), Continuous Cooling Transformation (CCT) and Continuous Heating Transformation (CHT) diagrams.

Metal Deformation

When a sufficient load is applied to a metal or other structural material, it causes the material to change shape. This change in shape is known as deformation.
It is caused either by the mechanical action of external forces or by various physical and physiochemical processes. The deformed or mechanically worked metals are far superior to cast metals.

DIL L78 Q/D/T (Deformation and Tension)

Tensile (load) tests and stress-strain curves

Stress-strain curves are an extremely important graphical measure of the mechanical properties of a material. The graph gives us many mechanical properties such as e-moduls, tensie strength and yiel strength.

The stress-strain diagram expresses a relationship between a load applied to a material and the deformation of the material caused by the load. The stress-strain diagram is determined by tensile testing. Tensile tests are performed in tensile testing machines (DIL L78 Q/D/T), which provide a controlled, uniformly increasing tensile force applied to the specimen.

DIL L78 Q

Our quenching dilatometers allow us to simulate production processes with complex temperature profiles for optimizing steels, alloys, and other metals. Especially for steels, many phase transitions come along with a change in density or at least a change in the expansion coefficient of the material. The simultaneous dilatation measurement of the L78 makes it therefore possible to detect phase transitions of the micro sturcture of the sample during the heat treatment cycle. This is of great importance for the optimization of your production processes.

DIL L78 Q

The DIL L78 **Q** is the basic version of the L78 series and allows for fast heating and **Q**uenching of samples and can be used for creating CHT, CCT and isothermal transformation diagrams

DIL L78 Q/D/T

DIL L78 Q/D

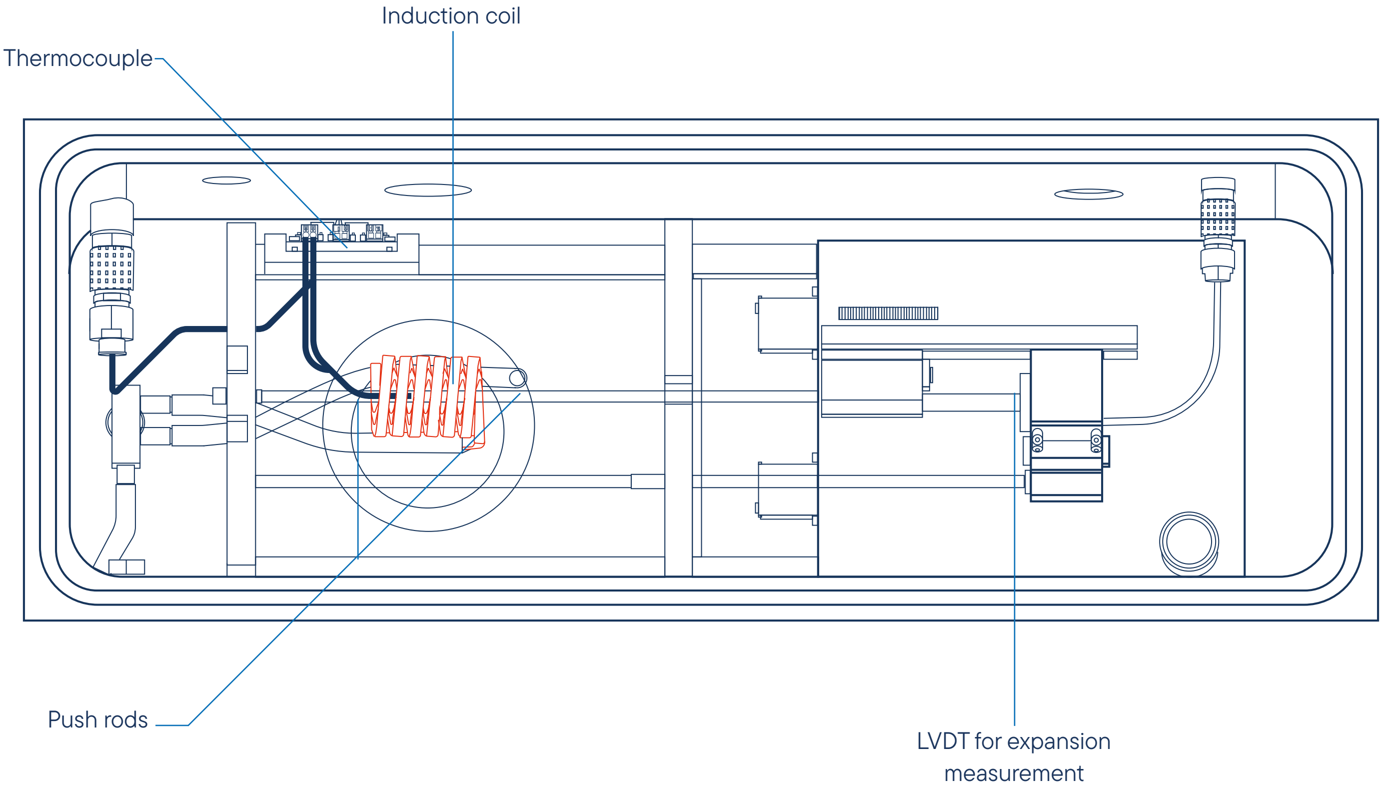
The L78 **Q/D** allows, in addition to the **Q**uenching dilatometer, for **D**eforming samples by applying compression.

DIL L78 Q/D/T

The L78 **Q/D/T** allows the full range of thermomechanical treatments: **Q**uenching, **D**eformation by compression, and **T**ensile testing.

Quenching mode

- Very low force
- CTE - Coefficient of Thermal Expansion
- Creation of TTT diagrams
- Determine phase changes at different cooling rates
- Maximum cooling: 4000 °C/s (hollow sample and maximum achievable cooling rate
- Low temperature option (T_{min} = -150 °C)
- Optional Laser speckle measurement of expansion (patent no. DE 10 2017 216 714.9)

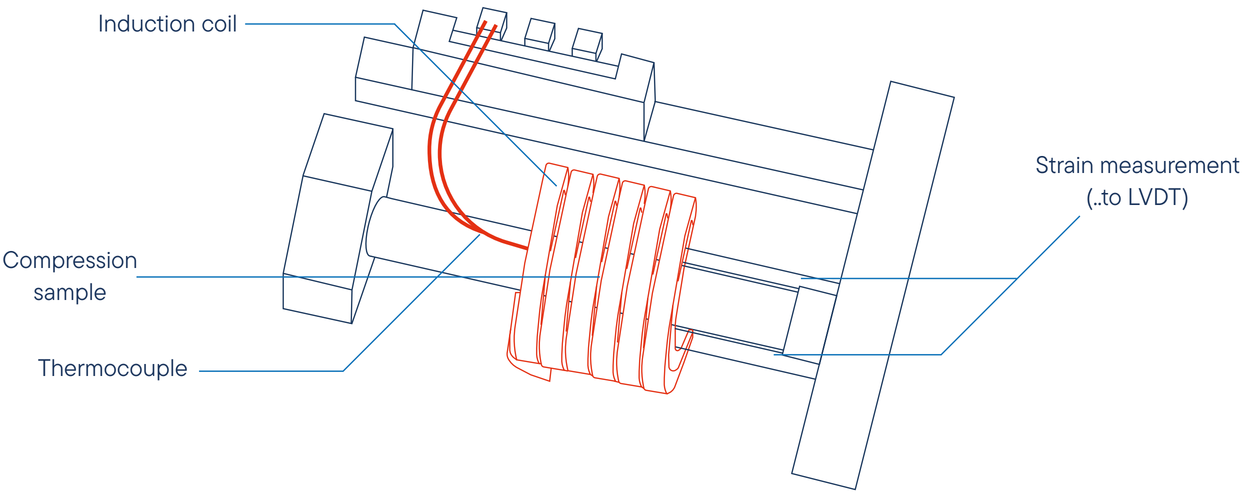


Accessories for Quenching mode

- Various turbomolecular pumps (standard and high flow)
- Thermocouple welder (optional inert gas mode)
- Cryogenic add-on (-150 °C in quench mode)
- Laser speckle option for 2-dimensional strain measurement
- -150°C in quenching mode, -50°C in tension und deformation mode

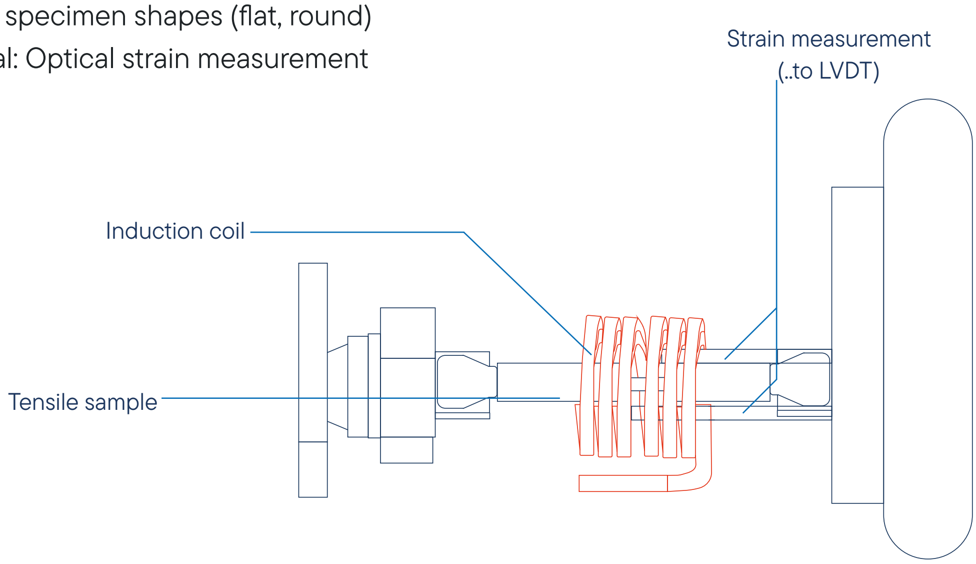
Deformation mode

- Simulation of manufacturing processes with mechanical stress such as hot rolling or forging
- Maximum cooling rate: 125 °C/s
  - Maximum force: 22 kN (compression)
  - Compression rate: 0.005 - 100 mm/s (more on request)



Tensile mode

- E-modulus determination
- Fracture Tests
- Maximum cooling rate: 125 °C/s
- Maximum force: 22 kN (tension)
- Tensile speed: 0.005 - 100 mm/s
- Various specimen shapes (flat, round)
- Optional: Optical strain measurement

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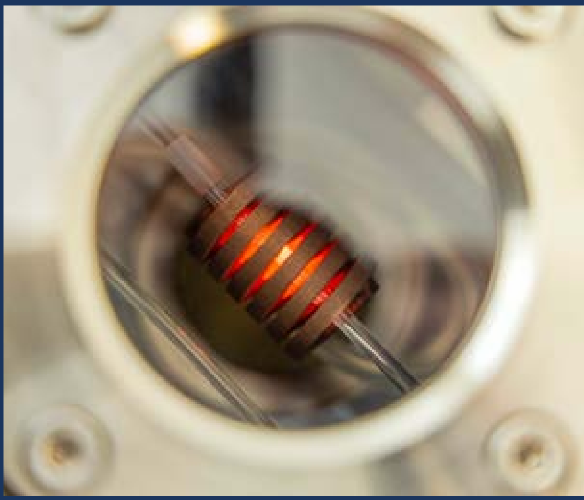
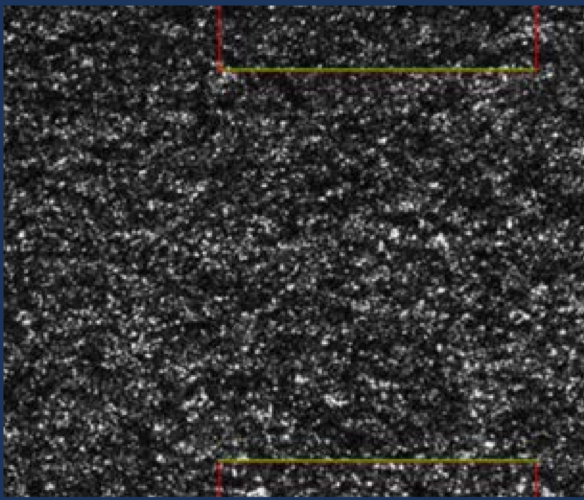
Unique features

Patented Precision with Speckle Analysis
The DIL L78 sets a new benchmark in thermal analysis with its patented speckle measurement technology. This innovative, non-contact method ensures unmatched precision in detecting minute displacements and deformations during thermal expansion processes. Perfect for applications demanding the highest level of accuracy.



Maintenance-Free Electrical Actuator
Designed for durability and reliability, the DIL L78 Q/D/T features a maintenance-free electrical actuator. Unlike traditional systems, this actuator eliminates the need for regular servicing, reducing downtime and operational costs, while ensuring smooth and consistent performance.

Laser Ultrasound Integration
The DIL L78 is equipped to combine seamlessly with laser ultrasound technology, enabling non-invasive, contact-free measurements with exceptional resolution. This powerful integration makes it ideal for challenging materials and complex analysis tasks, expanding the boundaries of thermal investigation.



DSC – Differential Scanning Calorimetry
Differential Scanning Calorimetry (DSC) is the most popular thermal analysis technique. It measures endothermic and exothermic transitions as a function of temperature.

Endothermic = heat flows into a sample
Exothermic = heat flows out of the sample

Accessoires

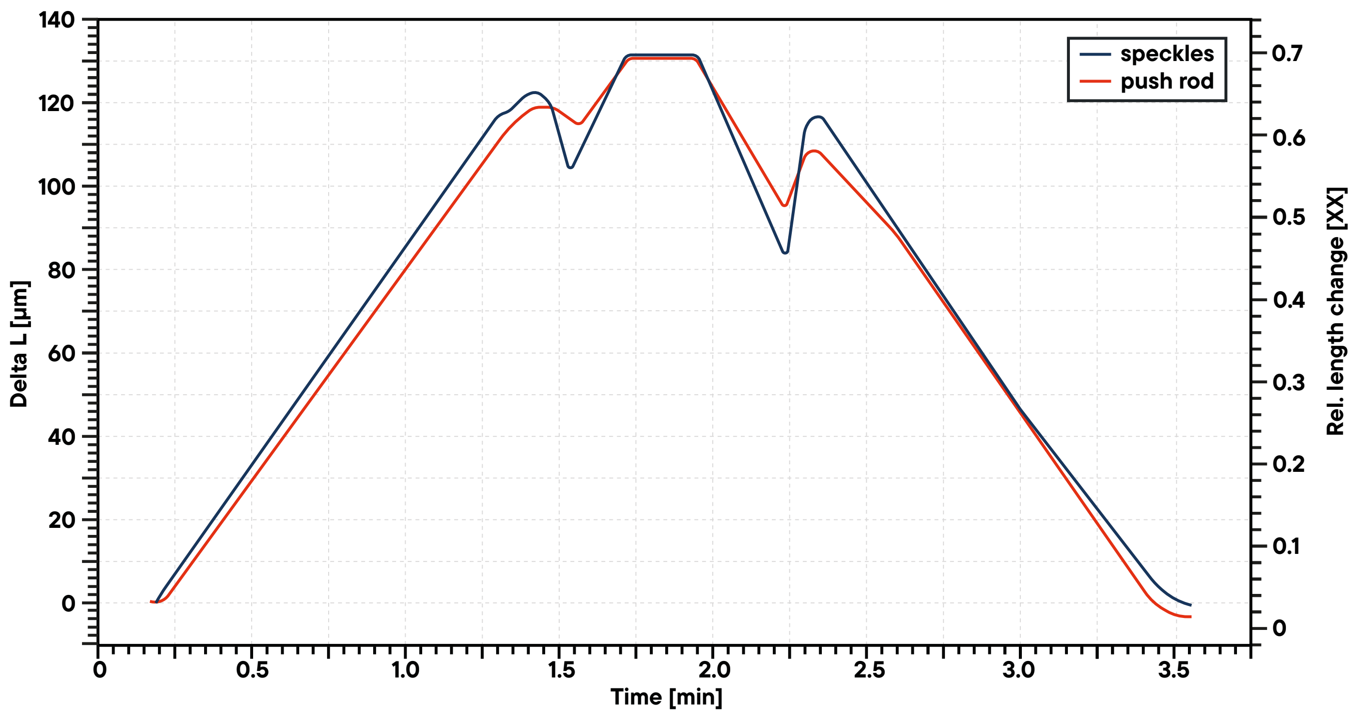
Laser speckle measurement of dilatation

- Optical Displacement Sensor / Optical Extensometer
- Camera observes speckle patterns generated by laser
- Camera images are evaluated after measurement
- Size and position of areas are user definable
- Up to 2 megapixel resolution
- Determination of anisotropy
- No markers required on sample
- 2D dot matrix for selectable areas
- Measure directly on the sample surface (no edge required)
- 2-dimensional measurement possible
- Small measurement area → small temperature gradient
- Length measurement very close to the thermocouple is possible
- Relatively small gap in the coil required

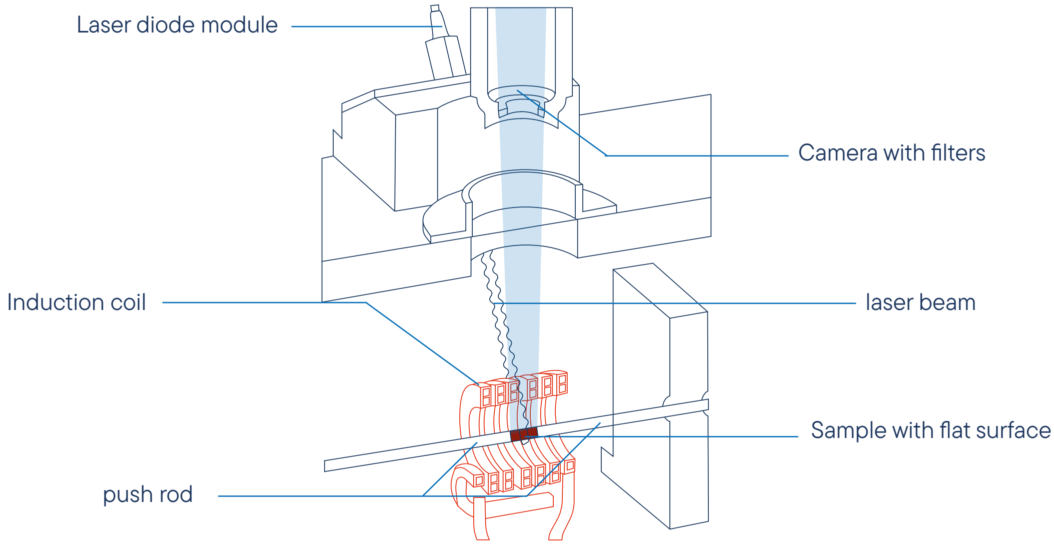
Technical Specifications

Resolution	1024x1024 px
Image size	1.6 x 1.6 mm³ ... 11 x 11 mm²

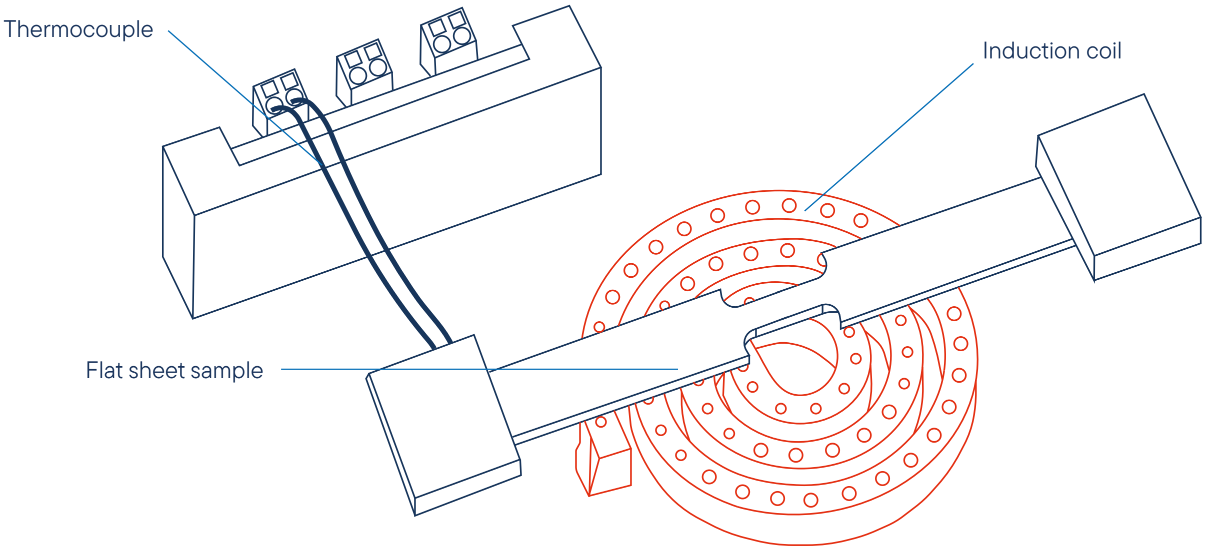
Comparison speckels vs push rod measurement



Quenching mode design



Tensile mode design



Non-destructive laser ultrasonic NDT technology

Real-time insight into the grain growth

The laser ultrasonic (LUS) nondestructive testing (NDT) technique allows in-situ grain size analysis based on the evaluation of the frequency-dependent ultrasonic attenuation *α(f)*, which is mainly caused by grain boundary scattering due to the applied method. The frequency-dependent ultrasonic attenuation is modeled by the following power law:

$$\alpha(f) = a+bfn$$

The attenuation coefficient *α(f)* is composed of an absorption coefficient α, a scattering coefficient *b*, the frequency *f* and the exponent *n*, where the absorption coefficient describes the internal friction losses and the scattering coefficient is the interesting grain size parameter (proportional to the mean grain size).
The exponent *n* results from the ratio of the acoustic wavelength to the mean grain size, where three types of scattering can be distinguished, Rayleigh (*n*=4), stochastic (*n*=2) and geometric scattering [1].

The relationship between the scattering coefficient and the grain size of interest *D* is modeled as follows:

$$\alpha(f)=a+C(D-D0)n-1fn$$

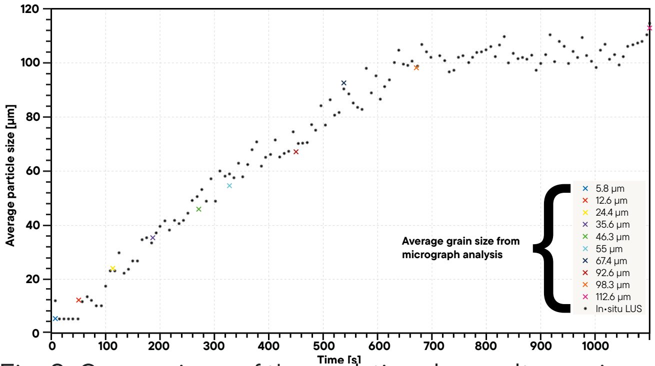


Fig. 2: Comparison of the real-time laser ultrasonic grain size calculations (points) with the micrograph analysis of quenched samples (colored X markings) of plain carbon steel AISI 1045

The scattering coefficient *b* is the product of the material dependent parameter *C* and the relative change in mean grain size *D*-*D*0 (*D*0 - initial grain size). Calibration of the model using mean grain size values from micrographs at specific temperature conditions yields the parameter *C* [2].

Figure 2 shows an impressive comparison of these real-time LUS results (dots) with several time-consuming micrograph analyses (colored X markers).

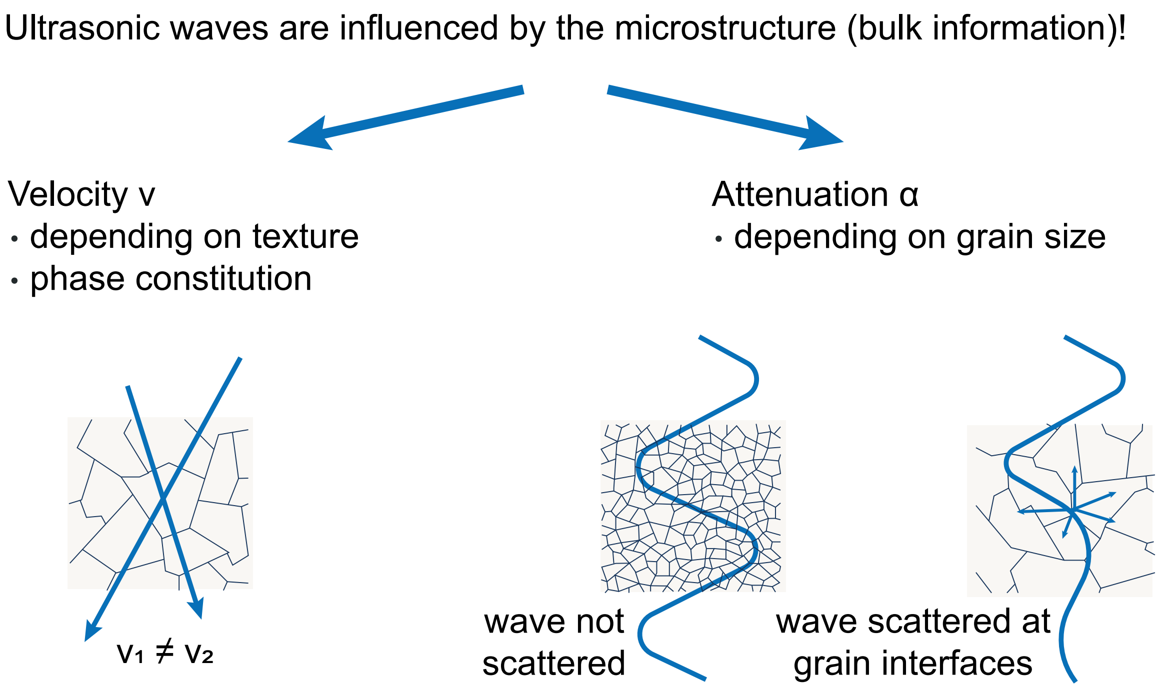
source:
[1] S. Sarkar, A. Moreau, M. Militzer, and W. J. Poole, "Evolution of austenite recrystallization and grain growth using laser ultrasonics," Metall. Mater. Trans. A Phys. Metall. Mater. Sci., vol. 39 A, no. 4, pp. 897–907, 2008, doi: 10.1007/s11661-007-9461-6.

[2] T. Garcin, J. H. Schmitt, and M. Militzer, "In-situ laser ultrasonic grain size measurement in superalloy INCONEL 718," J. Alloys Compd., vol. 670, pp. 329–336, 2016, doi: 10.1016/j.jallcom.2016.01.222.

Laser ultrasonic measurements and data analysis using this attenuation model provide real-time (in-situ) insight into the grain growth of a material during thermal cycling.
In-situ laser ultrasonic testing replaces time-consuming measurements and provides results in real time.

Real-time, in-situ measurement of:

- Recrystallization
- Grain growth
- Grain size
- Phase transitions
- Elastic constants



Software

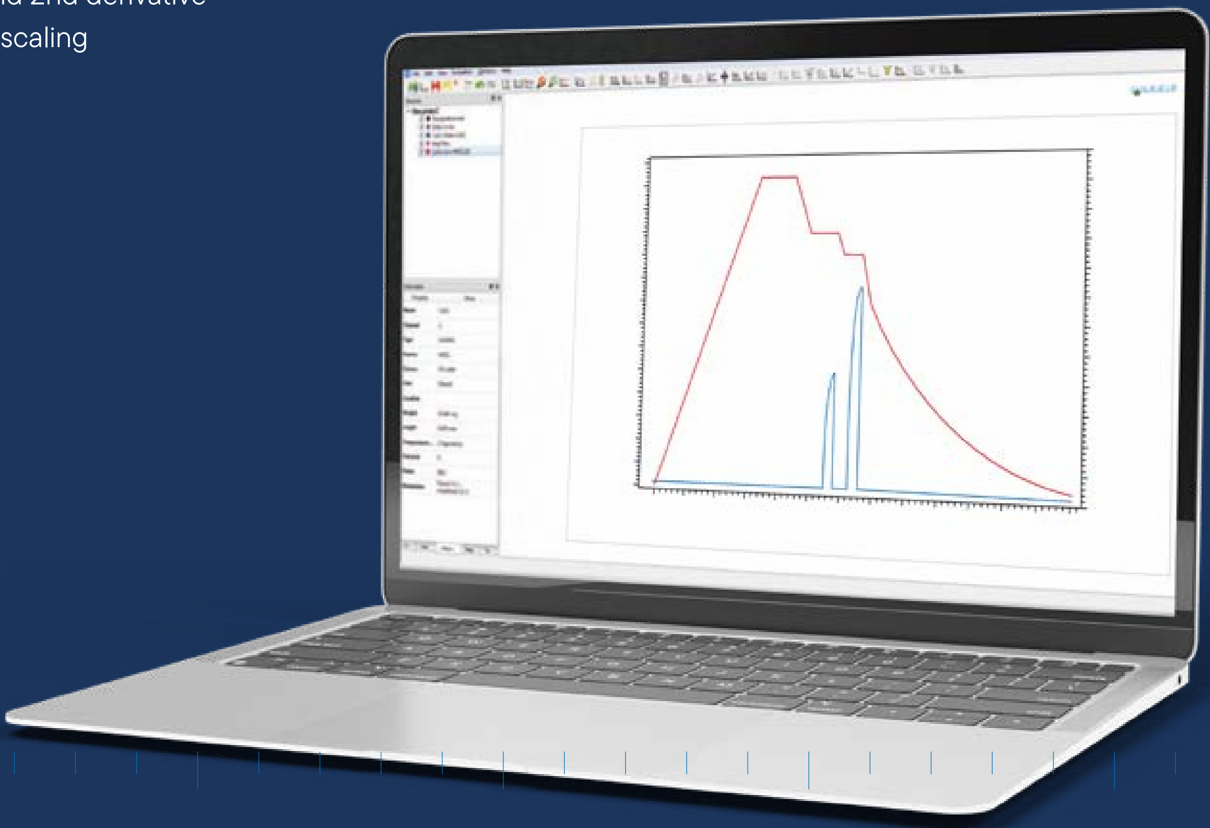
Our intuitive software interface ensures effortless operation, even for complex measurements. With its streamlined workflow, comprehensive data analysis tools, and real-time monitoring capabilities, the software empowers users to achieve reliable results with minimal training.

General Features

- Program capable of text editing
- Data security in case of power failure
- Thermocouple break protection
- Repetition measurements with minimum parameter input
- Evaluation of ongoing measurement
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- 1st and 2nd derivative
- Free scaling

DIL Features

- Display of relative/absolute shrinkage or expansion curves
- Presentation and calculation of technical/ physical expansion coefficient
- Semiautomatic evaluation functions
- Special Software package for creation of CCT / CHT / TTT diagrams

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Technical Specifications

L78 Q (Quenching)

Furnace	Induction Furnace
Temperature range	-150 °C up to 1600 °C (more on request)
Temperature measurement	up to 3 thermocouples welded to sample
Price range	$$
Sample geometry	ø 3 mm hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry (optional for heat treatment)	10x10x60 mm (others on request)
Heating rate	≤ 4000 K/s*
Cooling rate	≤ 4000 K/s*
Length change measurement	+/- 1.2 mm
Data sampling (for temperature, length, force)	up to 1 kHz
Length change resolution	5 nm
Data resolution	24-bit
Instrument dimensions	60x60x110 cm (without accessories)
Power supply	16 A, 208-230 V

*maximum heating/cooling rate, hollow sample

L78 Q/D (Quenching+Deformation)

Furnace	Induction Furnace
Temperature range	-150 °C up to 1600 °C (quenching mode) Sample dependent 1750 °C
Price range	$$$
Sample geometry quenching	ø 3 mm rec. hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry compression	solid samples, diameter 5 mm, 10 mm long
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Lenght change measurement Compression mode	+/- 5 mm
Length change measurement Quenching mode	+/- 1.2 mm
Length measurement resolution	5 nm (optional 1nm)
Compression force	22 kN (max)
Stroke rate	0.005 - 100 mm/s (more on request)
True strain (compression mode)	-0.02 to -1.2
Data sampling (for temperature, length, force)	up to 1 kHz
Mechanical control modes	stroke, force, true strain rate

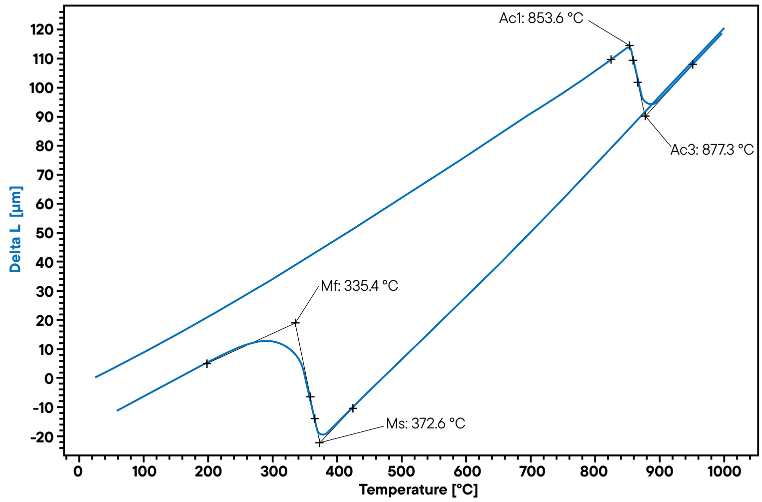
L78 Q/D/T (Quenching, Deformation and Tensile)

Furnace	Induction Furnace
Sample geometry quenching	Ø 3 mm rec. hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry compression	solid samples, diameter 5 mm, 10 mm long
Sample geometry tensile	round, flat sheet
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Length change measurement compression mode	+/- 5 mm
Length change measruement quenching mode	+/- 1.2 mm
Length measurement resolu-tion	5 nm (optional 1 nm)
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Compression/tensile force	22 kN (max)
Stroke rate (compression and tensile)	0.005 - 100 mm/s (more on request)
True strain (compression mode)	-0.02 to -1.2
Data sampling (for temperature, length, force)	up to 1 kHz
Mechanical control modes	stroke, force, true strain rate

DIL L78 Overview

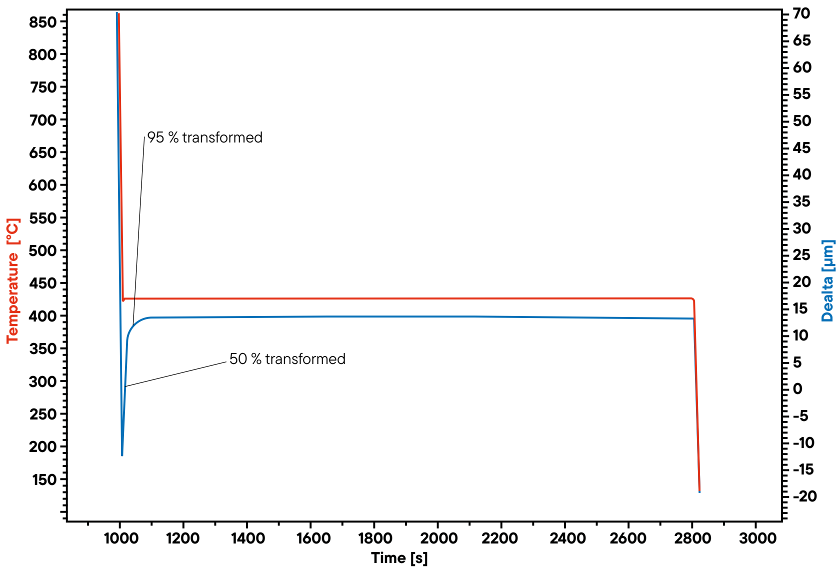
Applications DIL L78 RITA

Steel Phase Transformation



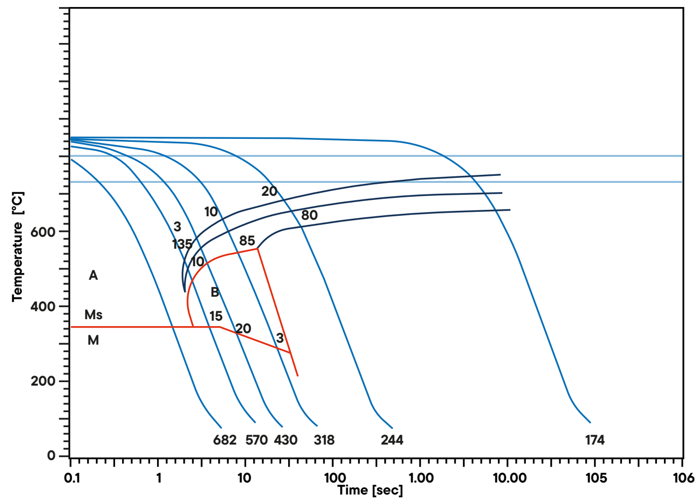
For creating a CCT diagram, the sample is quenched at different cooling rates. Depending on the cooling rate the sample may transform into different microstructures. The sample temperature and transformation start and end temperatures are transferred into the CCT diagram.

Isothermal transformation



The graphic on the left side shows length and temperature of a sample for creating a TTT diagram. While sample temperature remains constant the sample transforms into a different microstructure.

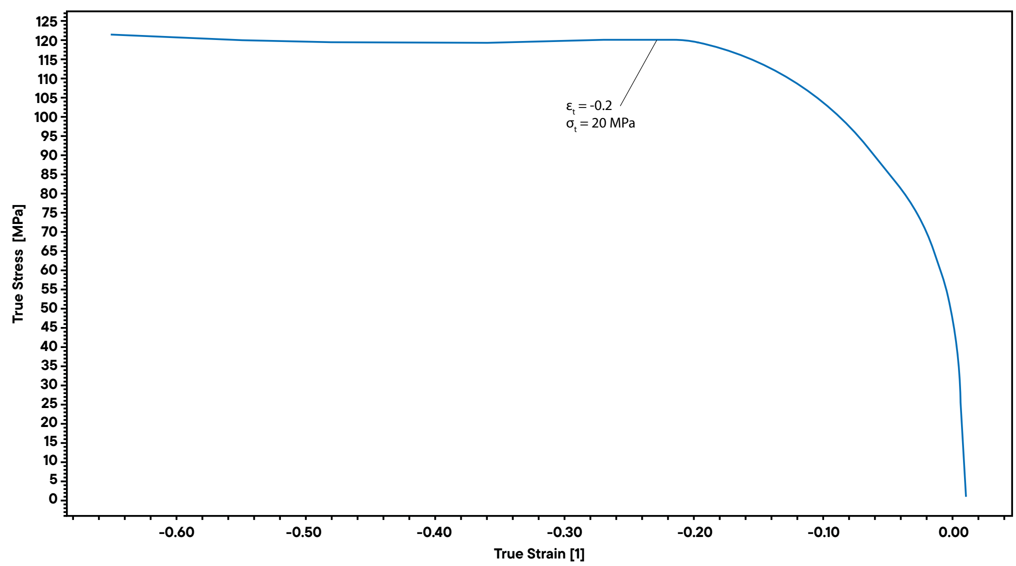
Continuous Cooling Transformation Diagram (CCT)



Picture © Dr. Sommer Werkstofftechnik GmbH, Issum

The CCT phase diagram represents the phase transformation of a material when it is cooled at various controlled rates. CCT diagram allow the prediction of the final microstructure of the measured steel. This crystalline structure determines the physical properties of the material. The L78 Q and L78 Q/D is the ideal tool to observe small dimensional changes under extreme conditions of controlled cooling. With the intuitive Software it is easy to prepare CCT, CHT and TTT diagrams from the test results.

Flow curve



The diagram shows the mechanical stress that is applied to the sample while the sample is compressed at a constant displacement rate or at a constant true strain rate. The sample shown here was compressed at 5 mm/s at 100 °C.

Linseis Service Lab

LINSEIS

pushing boundaries

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