Thermal Analysis Excellence

DSC 5+

STAR^{e} System

Innovative Technology

Versatile Modularity

Swiss Quality

Differential Scanning Calorimeter DSC 5+

The New Standard

METTLER TOLEDO

DSC Innovation
The Next Generation of Performance

Differential scanning calorimetry (DSC) measures enthalpy changes in a material due to changes in physical and chemical properties as a function of temperature or time. The DSC 5+ sets the new standard, delivering a superior performing and more productive DSC.

Features and benefits of the METTLER TOLEDO DSC 5+:

- **FlexMode™, choose power compensation or heat flux mode** – for optimal DSC performance
- **Power compensation** – provides outstanding resolution for separating close-lying effects
- **MultiSTAR™ sensor with 136 thermocouples** – exceptional sensitivity for the measurement of weak effects
- **Patented electrical heat flow adjustment** – saves time and ensures excellent measurement accuracy
- **Unrivalled modular concept** – tailor-made solutions for current and future needs
- **Time-saving FlexCal™ adjustment** – guarantees accurate results under all measurement conditions
- **Innovative robot with gas-purged crucible chamber** – protects samples from the environment and operates reliably around the clock

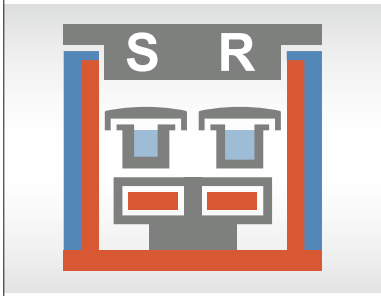
The revolutionary DSC sensor, with 136 thermocouples and 2 integrated heaters for power compensation mode, provides superior performance.

www.mt.com/ta-dsc

DSC Sensor
Power Compensation and Heat Flux

The DSC 5+ sensor with the FlexMode™ functionality can easily be switched between two different measurement modes. The robust and chemically resistant MMS 1 ceramic sensor provides a power compensation mode for excellent resolution and a heat flux mode for measurements that require high levels of sensitivity. This advanced sensor provides superior performance and allows the user to switch between modes to best suit the needs of the sample under investigation.

FlexMode™

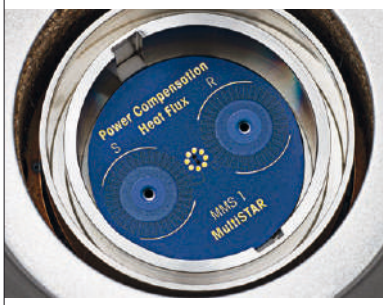


Choose between power compensation and heat flux mode depending on measurement requirements.

Power Compensation mode has a very short signal-time constant, providing excellent resolution and the ability to separate close-lying thermal effects.

Heat Flux mode has low levels of noise which provides the highest sensitivity for the detection of weak effects or transitions.

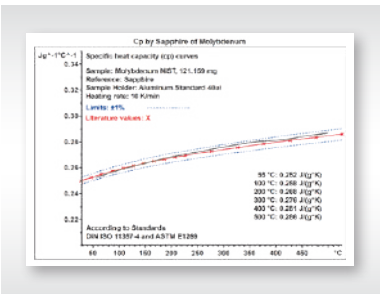
Power compensation



The single furnace power compensation mode is enabled by two heaters integrated into the sensor. During a measurement, the ΔT between the sample and reference positions is compensated by the heaters, so ΔT = 0.

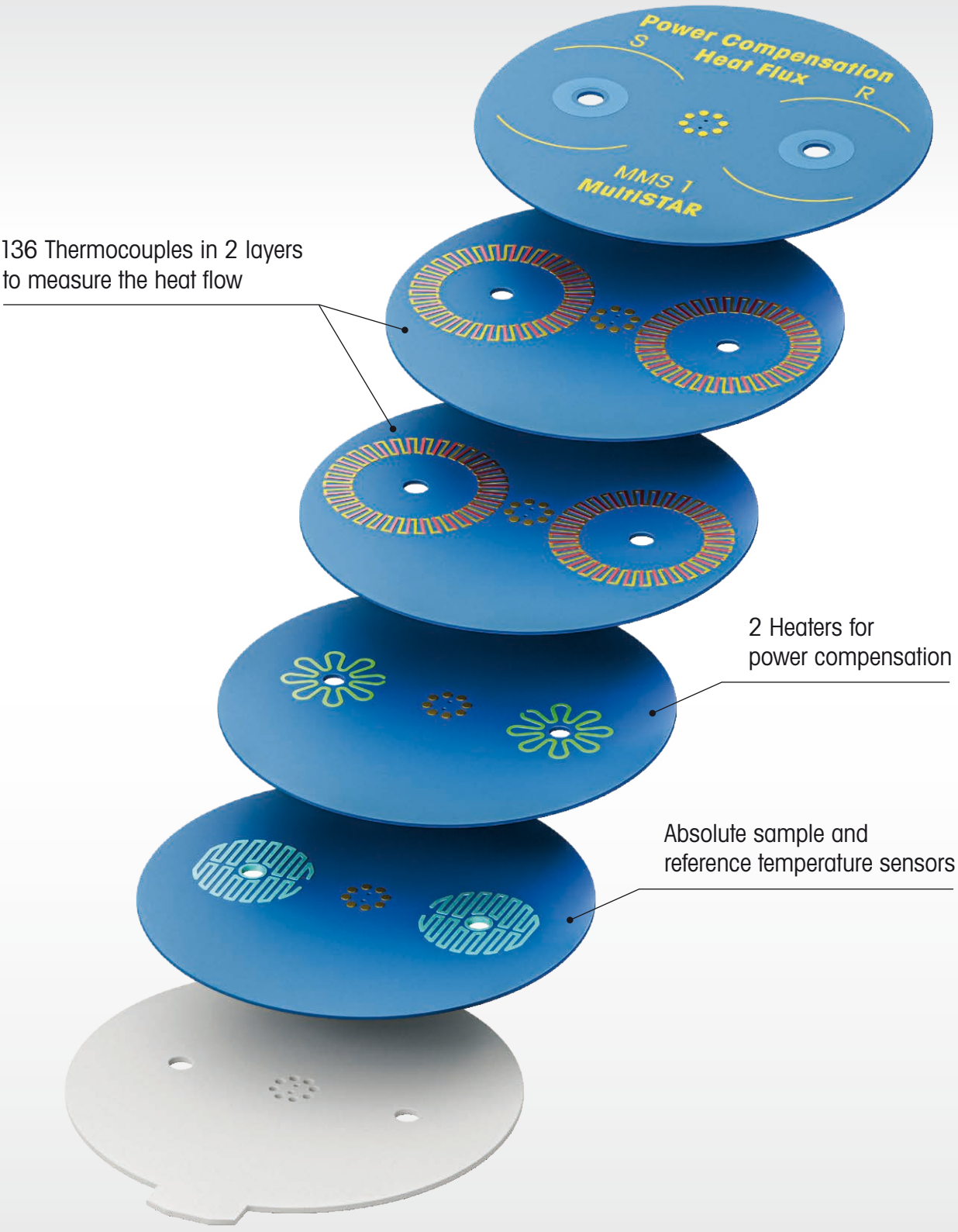
If there is an enthalpy change in the sample, the amount of heating power introduced to compensate is precisely measured, leading to a heat flow signal with excellent resolution.

Superior performance



The revolutionary MMS 1 sensor with the MultiSTAR™ thermocouple arrangement and a new optimized cell design provide world-class baseline quality and c_p accuracy.

This combination leads to a DSC with superior performance.



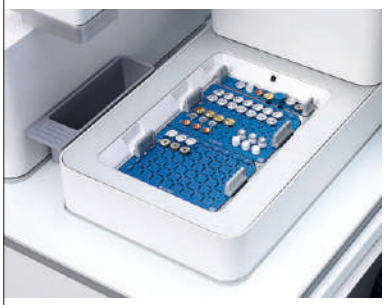
The innovative design of the sensor includes integrated heaters. This enables the sensor to accurately self-adjust for heat flow, resulting in a DSC that is always correctly adjusted over the entire temperature range. This advanced feature allows users to save valuable time and increase productivity with the automatic instrument adjustment.

Advanced Automation

24 Hours a Day, Just Like a Swiss Watch

Automation is more than just a sample robot. The DSC 5+ brings a combination of advanced hardware and software solutions resulting in a more productive DSC. The 3-axis sample robot, powerful STAR^{e} software, and the superior performance provided by the MMS 1 sensor allow you to perform more experiments, in a shorter time, with less resources.

96 samples



The environmentally-controlled crucible chamber stores up to 96 sample crucibles and 7 reference crucibles for continuous measurement.

The DSC 5+ can automatically detect two different tray types that handle crucible sizes ranging from 20 to 160 µL.

Crucible lid handling

For sensitive samples, a lid can be placed on the crucible and automatically removed before the measurement or, for hermetically sealed crucibles, pierced just before the measurement starts.

After the measurement, the robot can conveniently dispose of used crucibles into the crucible bin.

Software features

Our dedicated software solutions will help to streamline your workflows and free up operator time.

With features such as time-saving FlexCal™ adjustment, and autonomous result evaluation with the AIWizard™ software option, configure your STAR^{e} software to create fully-automated solutions that work for you.

www.mt.com/ta-software

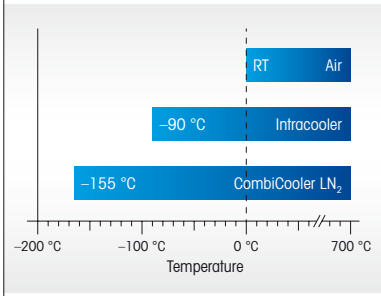
A more productive DSC – High-capacity sample robot with 96 sample positions, exchangeable reference, crucible lid piercing and environmental control is combined with FlexCal™ and the powerful STARe software, including AIWizard™, to increase your laboratory's efficiency.

www.mt.com/ta-automation

Temperature Options
Optimal Configuration

The DSC 5+ has an unrivalled modular concept. You can select the operating temperature to perfectly fulfill your measurement needs. This makes it an ideal choice for all laboratories, from industrial development and academic research to production and quality assurance.

Temperature range



The optimal configuration for your temperature requirements is always available!

Three available cooling options provide the following minimum temperatures for measurements:

Air: room temperature
Intracooler: –90 °C
CombiCooler: –155 °C

Furnace

Select the maximum operating temperature of your DSC 5+ with one of two silver furnace options:

- 500 °C
- 700 °C

CombiCooler

The DSC 5+ can be equipped with a CombiCooler. This allows the connection of both liquid nitrogen and an intracooler for maximum cooling flexibility.

Depending on the method, the instrument will automatically select the correct cooling device. This reduces the consumption of liquid nitrogen, because it is only used when required by the measurement conditions.

Combined LN_2 and Intracooler – automatic cooler selection reduces liquid nitrogen consumption over the entire temperature range.

www.mt.com/ta-accessories

Choose Your Configuration
Building a Complete System for Your Needs

Every laboratory has a different set of requirements for their measurement needs. We design our products to be fully modular and upgradable for a better user experience. Each option is chosen at the time of purchase but if your requirements change over time, the system can be easily upgraded, therefore protecting your investment.

Crucible chamber

When using the sample robot, a large number of samples can be stored in the crucible chamber.

To prevent unwanted interactions with the atmosphere before the samples are measured, the chamber can be purged with an inert gas, such as nitrogen.

Interactive touch screen

The DSC 5+ has an intuitive touch screen where the user can monitor the status of the instrument.

With our OneClick™ function, you can start frequently used methods quickly and easily. Simply select the predefined method, add the sample name and mass, and you are ready to measure.

Atmosphere control

We provide software-controlled mass flow controllers to measure and regulate the gas flow of up to 4 different method gases between 0 and 200 mL/min.

Perform measurements in a consistent and repeatable atmosphere or quickly switch gases with no effort.

Removable sample and reference crucible trays allow for easy sample preparation. The DSC 5+ will automatically identify the tray and select the correct sample for measurement.

Crucibles for Thermal Analysis
Guarantee Reliable Results

Crucibles serve as containers for samples during thermoanalytical measurements. They guarantee that the sensor is not contaminated by the measurement. The type of crucible used for a measurement can have a large effect on the quality of the results obtained, and in addition, also influences important characteristics of the DSC measuring cell. Considering the relevant factors before the measurement can often help to save time later on when interpreting the curve.

Extensive crucible range

We have the right crucible for every application. The crucibles are made of different materials with volumes ranging from 20 to 160 µL and for high pressures. All the different types can be used with the sample robot. Available crucibles can be found here:

▸ **www.mt.com/ta-crucibles**

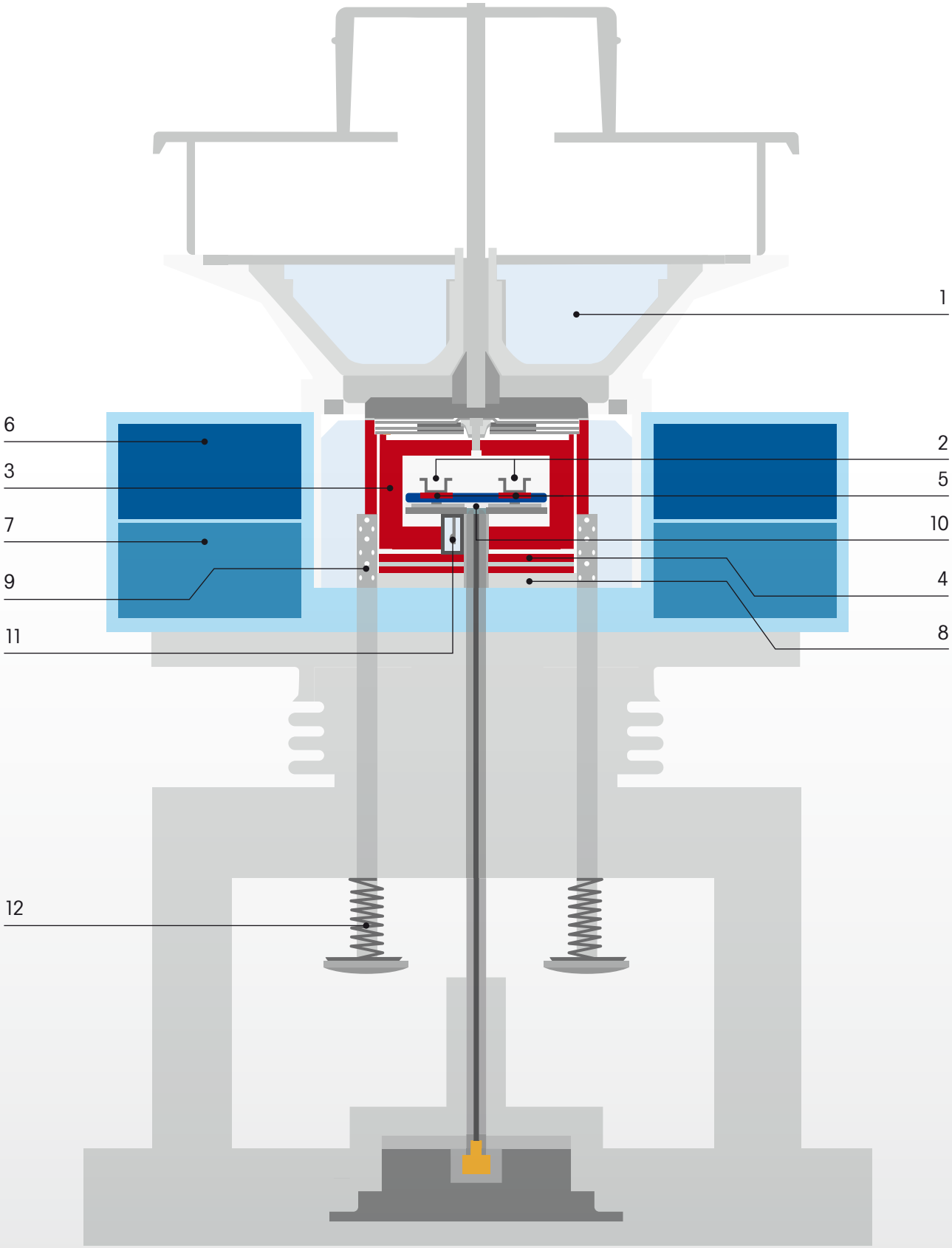
Crucible sealing press and sealing tools

The press allows the pan to be sealed very easily. Under the pressure of the plunger the pan is cold welded, hermetically sealing with the lid. After changing plunger and die you can use the press for other crucibles.

Crucible handling set

The crucible handling set provides a range of tools that are fundamental for sample loading and pan and lid handling:

- A funnel for filling the pan with sample
- Tweezers for handling of sample, pans and lids
- Different type of needles and a piece of rubber for lid preparation
- Crucible holder for crucible handling and safe bringing to the instrument



1. Furnace lid
2. Crucibles on the DSC sensor
3. Silver furnace
4. Flat heaters between two insulating disks
5. Heaters for power compensation
6. Liquid nitrogen cooling
7. Intracooler cooling
8. Thermal resistance for cooler
9. Cell gas outlet
10. Method gas outlet
11. Furnace temperature sensor
12. Compression spring construction

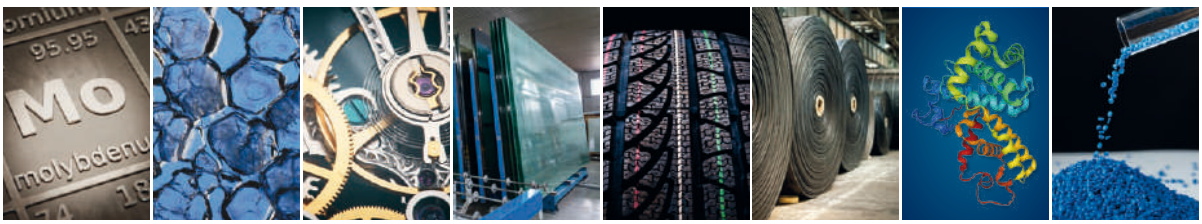
Extremely Wide Application Range
For All Kind of Materials

Differential scanning calorimetry measures the enthalpies associated with transitions and reactions and the temperatures at which these processes occur. The method is used for the identification and characterization of materials.

Differential scanning calorimetry (DSC) is fast and very sensitive. Sample preparation is easy and requires only small amounts of material. The technique is ideal for quality control, material development and material research.

Examples of thermal events and processes that can be determined by DSC

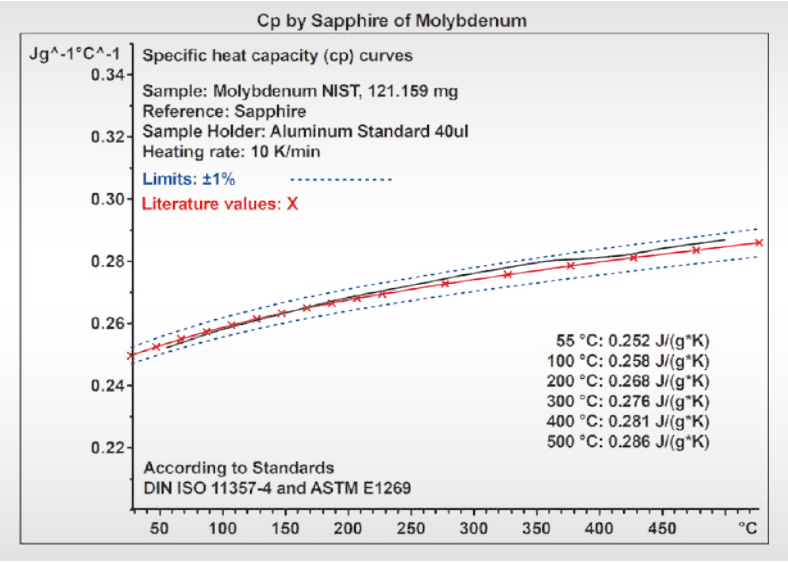
- Melting behavior
- Crystallization and nucleation
- ad Polymorphism
- Liquid-crystalline transitions
- Phase diagrams and composition
- Glass transitions
- Reactivity
- Reaction kinetics
- Curing
- Stability
- Miscibility
- Effects of plasticizers
- Thermal history
- Heat capacity and heat capacity changes
- Reaction and transition enthalpies
- Purity

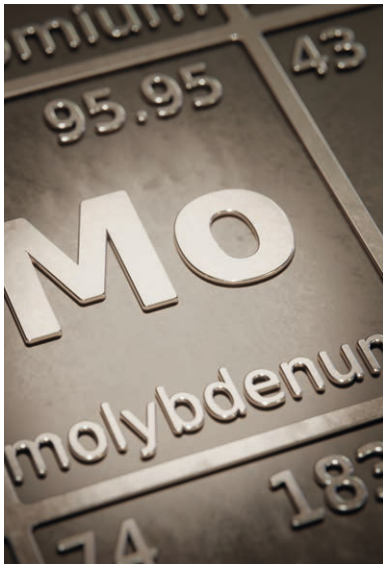


The method is used to analyze and study materials such as thermoplastics, thermosets, elastomers, composite materials, metals and alloys, adhesives, foodstuffs, pharmaceuticals and chemicals.

www.mt.com/ta-applications

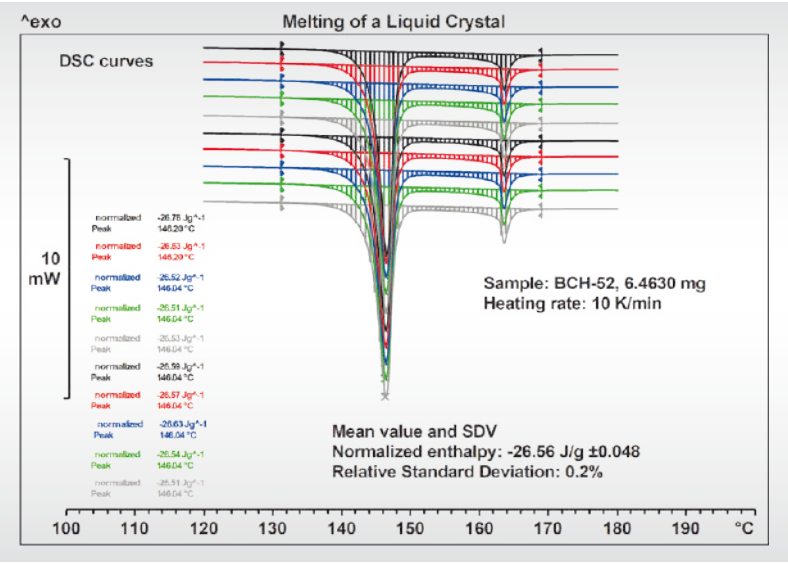
Specific heat capacity measurement

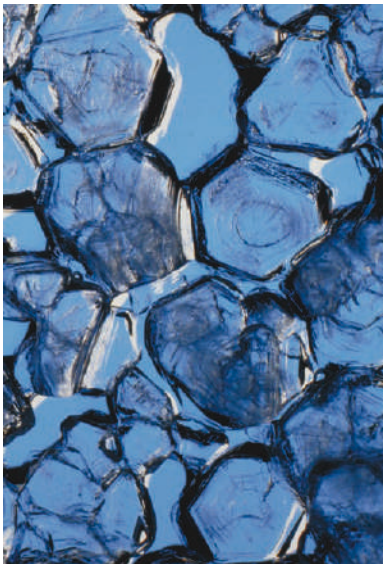




The determination of accurate values for the specific heat capacity of materials and substances is of great importance. Various methods exist to determine the specific heat capacity. Here, a metal sample (molybdenum) was examined in the power compensation mode while using the sapphire method as described in the standards DIN ISO 11357-4 and ASTM E1269. In the diagram, the specific heat capacity calculated is shown in relation to the documented specific heat capacity of the sapphire standard. The values agree very well with the literature values of molybdenum and give an accuracy within 2% across the temperature range from 50 to 590 °C.

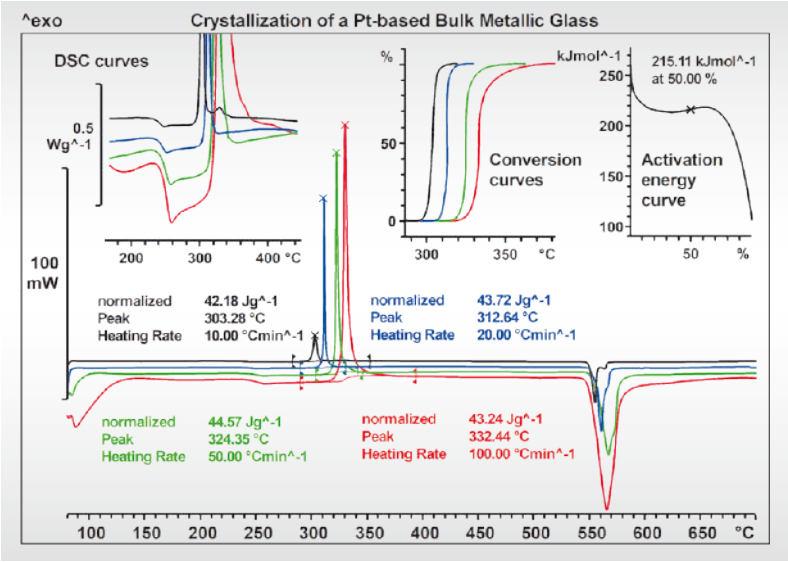
Enthalpy reproducibility of an organic compound





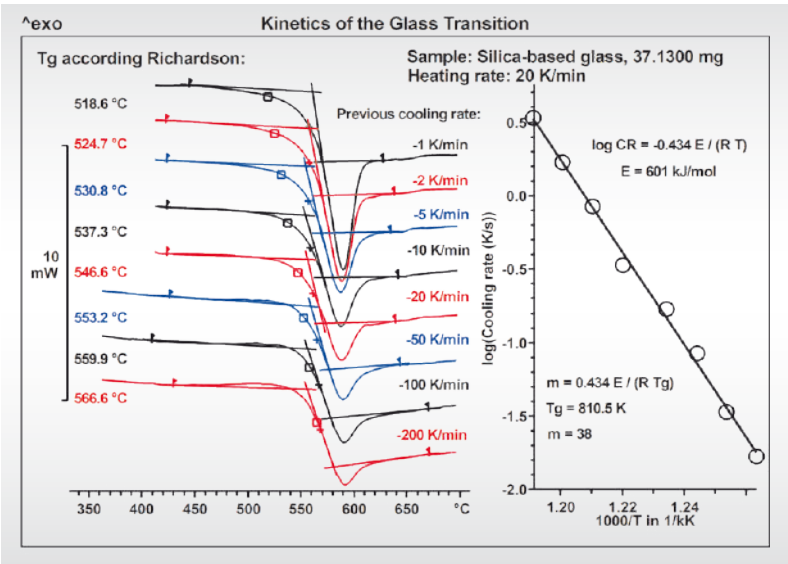
An excellent enthalpy reproducibility is key parameter for any DSC and is especially important for the reliable analysis of polymorphic material. To show the enthalpy reproducibility of the power compensation mode, an organic substance that neither decomposes nor sublimes during heating was measured. The same crucible containing around 6.5 mg of the liquid crystal BCH-52 was inserted and removed by the sample changer. The enthalpy of the melting peak (146 °C) and the following phase transition (164 °C) in ten consecutive runs were evaluated. The mean value and the standard deviation were calculated, and an enthalpy reproducibility (relative standard deviation) of 0.2% was achieved.

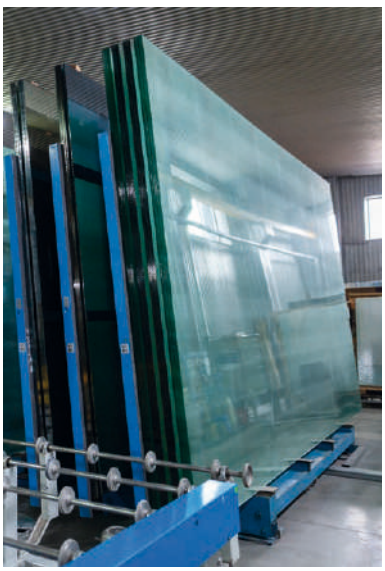
Crystallization of a bulk metallic glass



Bulk metallic glasses (BMG) are formed by cooling a metal alloy from the melt at high rates. BMGs are chemically resistant and possess a high strength. These amorphous alloys are used in modern applications that range from watch making to aerospace due to these unique properties. This example examines a Pt-based metal alloy measured in the power compensation mode. To evaluate the kinetics of the primary crystallization, measurements between 80 and 700 °C were performed at heating rates between 10 and 100 K/min. The curves show the glass transition (250 °C), crystallization (300–350 °C) and melting (ca. 550 °C). The upper diagrams are a magnification of the glass transition range, conversion curves calculated from the crystallization peaks for the model-free-kinetics evaluation and the resulting apparent activation energy.

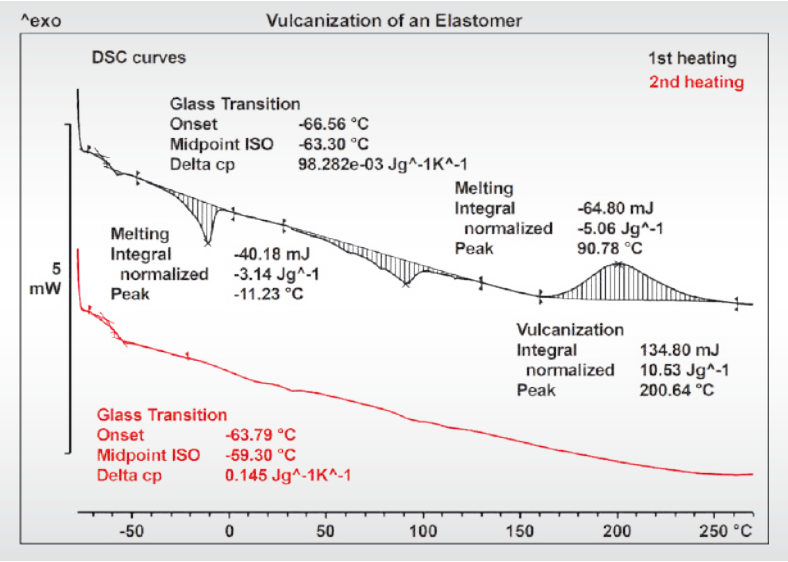
Kinetics

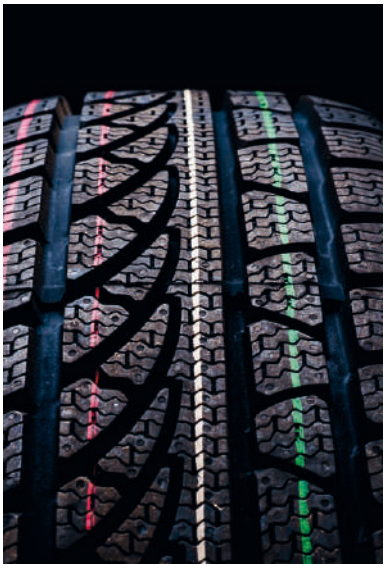




The kinetics of the glass transitions (T_g) is related to the stability of glasses, which is important in a wide range of applications from pharmaceuticals to inorganic glasses. Here we show an example of a silica-based glass with a T_g above 500 °C. The kinetics of the T_g was studied by measurement of the cooling rate dependence between 1 and 200 K/min in the power compensated mode. After each cooling, the sample was heated with 20 K/min to determine the T_g. The limiting fictive temperature according to Richardson characterizes the structure of the glass after cooling and delivers the apparent activation energy E = 601 kJ/mol from the slope in the right diagram. This value is related to the fragility parameter m = 38, an indication for a strong glass former.

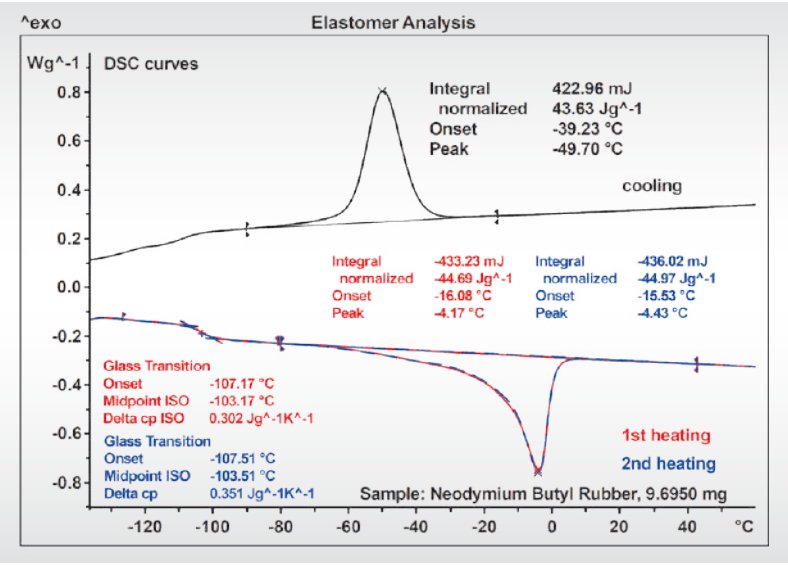
Vulcanization of an elastomer





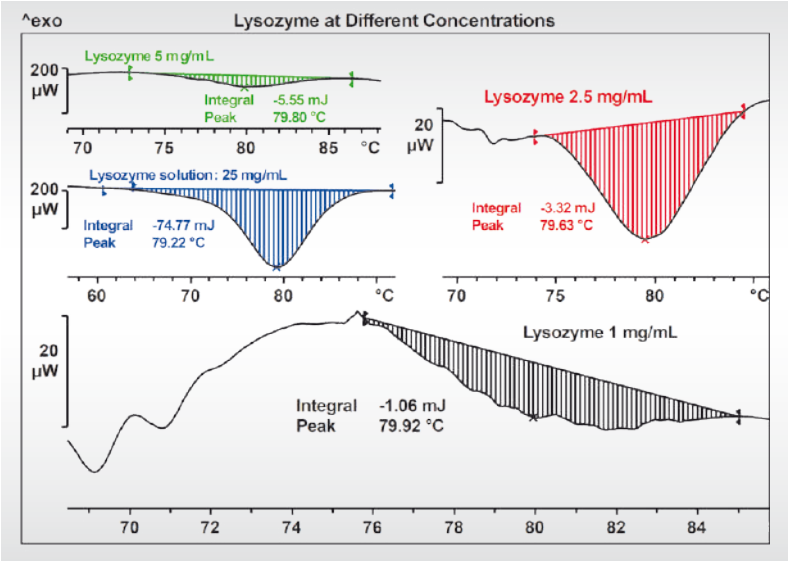
Vulcanization (or cross-linking) is a chemical process used to harden rubbers. The double bonds of the polymer chains are broken, and sulfur atoms form bridges or cross-links between the chains. Here a rubber sample undergoes the vulcanization inside the DSC 5+. During the first heating (black), a glass transition is observed at around –63 °C. It is followed by two small melting peaks (–10 and 90 °C). The vulcanization, an exothermic and irreversible effect, starts at about 150 °C and is complete at 250 °C. The specific enthalpies of reaction depend on the filler content, the cross-linking system and the cross-linker content. In the second heating, only the glass transition of the vulcanized rubber is observed at –60 °C.

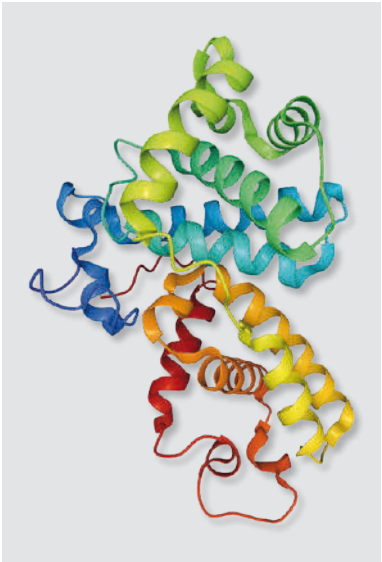
Elastomer analysis



Elastomers are designed to be used in a temperature range between their glass transition (T_g) and melting point (T_m). This range is dubbed the "rubbery plateau". The T_g for elastomers is generally well below 0 °C, therefore liquid nitrogen is often used to cool the DSC. In this case, an elastomeric sample was measured in the heat flux mode, the method consisted of a heating-cooling-heating cycle starting at room temperature in a nitrogen atmosphere according to ISO 1135. The 1st and 2nd heating curves show excellent reproducibility for determination of the T_g (–107 °C) and T_m (–4 °C).

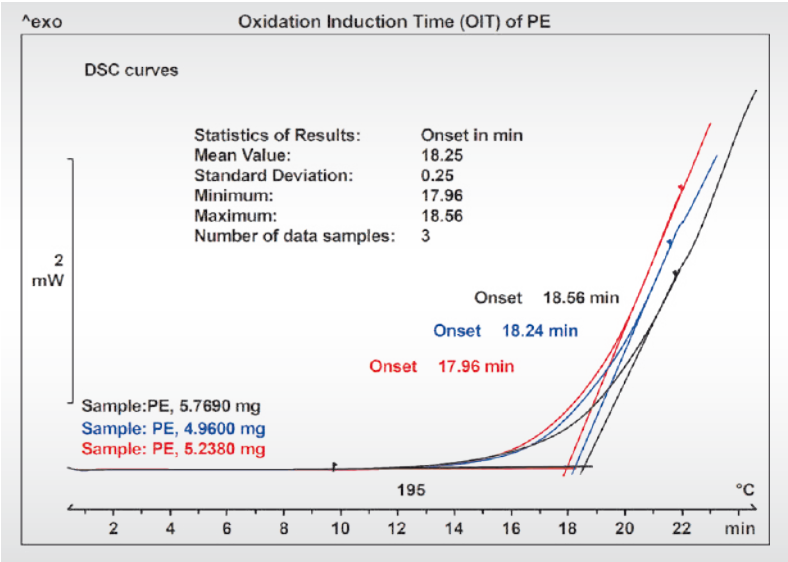
Unfolding of dissolved lysozyme





Proteins have a low enthalpy of denaturation, and it occurs over a broad temperature range. This makes it difficult to measure them on a DSC. However, here we show the unfolding of a sample of lysozyme dissolved in a buffer solution (pH 4.0). The heat flux mode was used to measure the endothermic peak of denaturation of lysozyme at concentrations down to 1 mg/mL. The solution was heated from 30 to 92 °C at 3 K/min. The reference crucible was loaded with an identical volume of glycine buffer. The protein denatured between 79.2 and 79.9 °C.

Oxidation induction time OIT

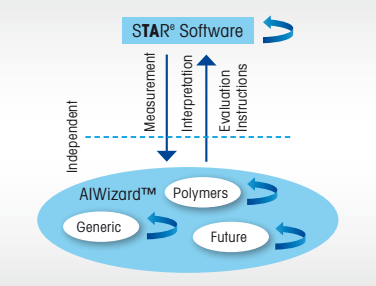


The oxidation induction time (OIT) determination is an accelerated thermal aging test. It is widely used to investigate the oxidative stability of oils, polymers, and foods, as well as in process development and quality control. Several important standards describe standard test procedures for the determination of OIT at ambient pressure using DSC. Here, a measurement of a polyethylene was performed in the heat flux mode according to the standards ISO 11357-6/ASTM D3895 at an isothermal temperature of 195 °C. The results of a triple determination are very well reproducible.

Easy, Intuitive Operation
Uncomplicated, Efficient and Safe

STARe is the most complete and comprehensive thermal analysis software on the market and provides unrivalled flexibility and unlimited evaluation possibilities. The flexible STARe software consists of the base software and a large number of application-specific options to satisfy your current and future requirements.

AIWizard™

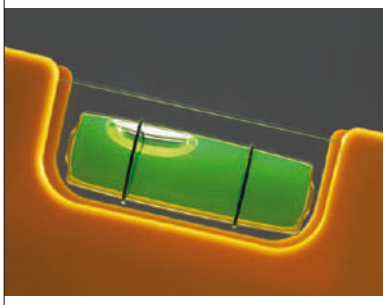


Evaluating thermal analysis results leaves many analysts questioning:
- What is the type of effect?
- Where does the effect begin and end?

The AIWizard automatically identifies and evaluates all thermal effects measured by DSC. Comprised of a trained neural network that utilizes thousands of evaluation examples, the system is able to determine all thermal effects.

www.mt.com/ta-aiwizard

FlexCal™



FlexCal is a unique tool that reduces the time needed for instrument adjustment by storing adjustment parameters for each combination of module, crucible, and gas type in a database. Depending on the method, the module applies the correct adjustment parameters, even if the gas type is switched during the measurement.

No extra adjustment is necessary, saving valuable time for the operator. Watch our webinar to learn how FlexCal ensures good results, even when test conditions change:

www.mt.com/ta-calibration

EvalMacro and Quality Control

EvalMacro lets you predefine limits for consistent curve evaluation of known samples, regardless of the operator. You can also define an automatic assessment to confirm whether results are within specification.

The QC option allows users to automatically track product quality, compare curves and store results in material-specific tables. Statistics are displayed for each table, allowing any deviations to be tracked over time. Evaluation, assessment, and data transfer to the statistics table can be fully automated in the method.

www.mt.com/ta-evalmacro
www.mt.com/ta-qc

A complete thermal analysis system consists of six complementary measuring techniques, each bringing fast and accurate results. Additional knowledge and information about your sample can be obtained by using a variety of hyphenated techniques.

World-Class Service and Support
Provide Results You Can Trust

METTLER TOLEDO's portfolio of services is designed to ensure the continuous performance and reliability of your thermal analysis systems. Factory-trained in Switzerland, our worldwide teams bring the professional expertise and know-how needed to provide you with the highest level of after-sales support, as well as the experience necessary to optimize services for your own particular needs.

Thermal Analysis Application

Hundreds of interesting articles on thermal analysis are now available from METTLER TOLEDO. They describe new applications, review analytical topics or give practical tips on how to perform and evaluate measurements.

www.mt.come/ta-application

Video Library

A large library of product videos as well as more technical "How to" videos is provided.

www.mt.com/ta-videos

TA eNewsletter

A quarterly eNewletter to help you get the most out of your thermal analysis system. A typical TA eNewsletter will include:

- A TA tip in line with current Good Laboratory Practice (GLP)
- Upcoming events (e.g. live webinars, training courses, conferences)
- Links to our most recent applications, guides, handbooks and videos

www.mt.com/ta-knowledge

The DSC 5+ sets the new standard for differential scanning calorimeters, providing you a superior performing and more productivity DSC.

DSC 5+ Specifications

Temperature data

Temperature range	Air	RT to 500 °C	RT to 700 °C
	Intracooler	–90 to 500 °C	–90 to 700 °C
	Liquid nitrogen	–155 to 500 °C	–155 to 700 °C
Temperature accuracy [1]		± 0.2 K	
Temperature precision [1]		± 0.02 K	
Heating rate (RT to 700 °C) [2]		0.001 to 200 K/min	
Cooling rate [2]		0.001 to 50 K/min	
Cooling time	Air	8 min (700 to 100 °C)	
	Intracooler	3.5 min (100 to 0 °C)	
	Liquid nitrogen	11 min (100 to –100 °C)	

Calorimetric data

Measurement Mode		Power Compensation	Heat Flux
Sensor		MMS 1	
Sensor material		Ceramic	
Number of thermocouples		136	
Number of embedded heaters		2	not active
Signal time constant		0.7 s	2.4 s
Indium peak (H to W)	raw data [3]	25.0	12.6
TAWN [4]	resolution	4.0	2.5
	sensitivity	66.0	22.1
Measurement range [5]	at 156 °C	± 375 mW	± 325 mW
	at 700 °C	± 350 mW	± 188 mW
Resolution		0.1719 nW	

Sampling

Data rate	maximum 50 values per second

Special modes

ADSC	standard
IsoStep™	standard
TOPEM™	optional
Automation	optional

[1] Based on metal standards.
[2] Depends on instrument configuration.
[3] No mathematical treatment to the data or correction applied.
[4] TAWN tests for quantitatively measuring the resolution and sensitivity of DSCs (version 2.1).
[5] The measurement-range depends on the adjustment and hence method-gas and crucible.

Approvals

IEC 61010-1:2010 A1 & -2-010:2019 & -2-081:2019EN
61010-1:2010 A1:2019 & -2-010:2020 & -2-081:2020
CAN/CSA-C22.2 No. 61010-1-12 & -2-010-15 & -2-081-15
UL Std. No. 61010-1 (3rd Edition)
IEC61326-1:2020 / EN61326-1:2021 (class B)
IEC61326-1:2020 / EN61326-1:2021 (industrial requirements)
FCC 47 CFR Part 15, class B
ICES-001, Issue 5, class A
AS/NZS CISPR 11, AS/NZS 61000-3, AS/NZS 61000-4
EN 63000:2018
Conformity mark: CE

Specifications and approvals for the IntraCooler option are only valid for systems with Huber coolers.

www.mt.com/ta
For more information

METTLER TOLEDO Group
Analytical Instruments
Local contact: www.mt.com/contacts

30848569
Marketing MatChar / MarCom Analytical

Quality certificate. Development, production and testing according to ISO 9001.

Environmental management system according to ISO 14001.

"European conformity". The CE conformity mark provides you with the assurance that our products comply with the EU directives.