More worldwide customers choose TA Instruments than any competitor as their preferred thermal analysis or rheology supplier. We earn this distinction by best meeting customer needs and expectations for high technology products, quality manufacturing, timely deliveries, excellent training, and superior after-sales support.

SALES AND SERVICE
We pride ourselves in the technical competence and professionalism of our sales force, whose only business is rheology and thermal analysis. TA Instruments is recognized worldwide for its prompt, courteous, and knowledgeable service staff. Their specialized knowledge and experience are major reasons why current customers increasingly endorse our company and products to their worldwide colleagues.

INNOVATIVE ENGINEERING
TA Instruments is the recognized leader for supplying innovative technology, investing twice the industry average in research and development. Our new Q Series™ Thermal Analysis modules are the industry standard. Patented innovations like Modulated DSC®, Tzero™ technology, and Hi-Res™ TGA are available only from TA.

QUALITY PRODUCTS
All thermal analyzers and rheometers are manufactured according to ISO 9001: 2000 procedures in our New Castle, DE (USA) or our Crawley, UK facilities. Innovative flow manufacturing procedures and a motivated, highly-skilled work force ensure high quality products with industry-leading delivery times.

TECHNICAL SUPPORT
Customers prefer TA Instruments because of our reputation for after-sales support. Our worldwide technical support staff is the largest and most experienced in the industry. They are accessible daily by telephone, email, or via our website. Multiple training opportunities are available including on-site training, seminars in our application labs around the world, and convenient web-based courses.

New Castle, DE USA - 1-302-427-4000 • Crawley, England - 44-01293-658900 • Brussels, Belgium - 32-2-706-0080 • Paris, France - 33-1-30-48-94-60
Etten-Leur, Netherlands - 31-76-508-7270 • Alzenau, Germany - 49-6023-96470 • Milano, Italy - 39-02-27421-283 • Barcelona, Spain - 34-93-600-9300
Melbourne, Australia - 61-3-9553-0813 • Stockholm, Sweden - 46-8-59-46-92-00 • Tokyo, Japan - 81-3-5479-8418 • Shanghai, China - 86-21-63621429
Differential Scanning Calorimeters

Technology, performance, versatility, and reliability are words that describe a TA Instruments Q Series™ Differential Scanning Calorimeter (DSC). The Q1000, Q100, Q10, and Q10P are fifth-generation products from the world leader in differential scanning calorimetry. Each represents an unparalleled investment because it delivers cutting-edge technology, is designed with the customer in mind, and is backed by superior support that is the hallmark of our company.
**TA INNOVATIONS**

**Differential Thermal Analysis**

*Heat Flux DSC*

*Pressure DSC*

*First Microprocessor Controlled Calorimeters*

*First Automated DSC*

*Dual Sample DSC*

*Differential Photocalorimetry*

*Modulated DSC®*

*Tzero™ DSC Technology*
The Q1000 is TA Instruments' top-of-the-line, research-grade DSC, with unmatched performance in baseline stability, sensitivity, and resolution. It contains Advanced Tzero™ technology, the most powerful DSC technology commercially available. Its industry leading features include Modulated DSC™, a 50-position intelligent autosampler, and digital mass flow controllers. Photo-calorimetry and pressure DSC accessories are also available, making the Q1000 the best-equipped analyzer to meet the needs of the most demanding researcher.

The Q100 is a versatile, research-grade DSC with our patented Tzero™ technology. With many Q1000 performance features, the Q100 easily outperforms competitive research models. It is an expandable module, to which MDSC®, a 50-position autosampler, or a photocolorimeter can be added. Innovative technology, performance, upgradability, and ease-of-use make the Q100 a superb addition to any laboratory.

The Q10 is a cost-effective, easy-to-use, general-purpose DSC with basic performance features equivalent to many competitive research-grade models. It is ideal for research, teaching, and quality control applications that require a rugged, reliable, basic DSC.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Q1000</th>
<th>Q100</th>
<th>Q10</th>
<th>Q10P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tzero™ Technology</td>
<td>Advanced</td>
<td>Basic</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>MDSC®</td>
<td>Included</td>
<td>Optional</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Direct Cp Measurement</td>
<td>Yes</td>
<td>Not Available</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Touch Screen</td>
<td>Included</td>
<td>Included</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>User-Replaceable Cell</td>
<td>Yes</td>
<td>Not Available</td>
<td>Not Available</td>
<td>Yes</td>
</tr>
<tr>
<td>Pressure DSC Cell</td>
<td>Optional</td>
<td>Not Available</td>
<td>Not Available</td>
<td>Yes</td>
</tr>
<tr>
<td>Photocalorimeter</td>
<td>Optional</td>
<td>Optional</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Digital Mass Flow Controller</td>
<td>Included</td>
<td>Included</td>
<td>Included</td>
<td>Not Available</td>
</tr>
<tr>
<td>50-Position Autosampler</td>
<td>Included</td>
<td>Optional</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Auto Lid</td>
<td>Included</td>
<td>Included</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Temperature Accuracy</td>
<td>± 0.1 °C</td>
<td>± 0.1 °C</td>
<td>± 0.1 °C</td>
<td>± 0.1 °C</td>
</tr>
<tr>
<td>Temperature Precision</td>
<td>± 0.01 °C</td>
<td>± 0.01 °C</td>
<td>± 0.01 °C</td>
<td>± 0.05 °C</td>
</tr>
<tr>
<td>Temperature Range (with cooling accessory)</td>
<td>-180 to 725 °C</td>
<td>-180 to 725 °C</td>
<td>-180 to 725 °C</td>
<td>-130 to 725 °C</td>
</tr>
<tr>
<td>Calorimetric Precision (metal standards)</td>
<td>± 0.1%</td>
<td>± 0.1%</td>
<td>± 0.1%</td>
<td>± 1%</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.2 µW</td>
<td>0.2 µW</td>
<td>1.0 µW</td>
<td>1.0 µW</td>
</tr>
<tr>
<td>Baseline Curvature with Tzero (-30 to 300°C)</td>
<td>10 µW</td>
<td>10 µW</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Baseline Reproducibility with Tzero</td>
<td>±10 µW</td>
<td>±10 µW</td>
<td>&lt;0.04 mW</td>
<td>Not Available</td>
</tr>
<tr>
<td>Relative Resolution</td>
<td>2.9</td>
<td>2.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
**Tzero Cell Design**

The Tzero™ cell is designed for excellence in both heating and cooling operation. Its many innovations include a new sensor with raised sample and reference platforms. The sensor is machined for symmetry from a single piece of durable, thin wall, high response constantan and brazed to the silver heating block. **Benefits:** Provides faster signal response, flat baselines, superior sensitivity and resolution, plus improved data precision.

A new chromel/constantan Tzero thermocouple is located midway between the sample and reference sensor platforms. **Benefits:** It provides for independently measured sample and reference heat flows that produce superior DSC and MDSC® results. It simultaneously acts as a control sensor to assure precise isothermal furnace operation.

Matched chromel area thermocouples are welded to the underside of each sensor platform and provide superior performance to other thermocouple designs. **Benefits:** High sensitivity detection of any temperature transition that results from a physical change in the sample.

**Auto Lid**

The Q1000 and Q100 have a new and improved auto lid assembly that consists of dual silver lids and a dome-shaped heat shield. The auto lid automatically covers and uncovers the cell as necessary. The Q10 lid assembly is manually operated. **Benefits:** More accurate measurements result from improved thermal isolation of the cell.
**Cooling Rods & Ring**

The innovative design features an array of 54 symmetrically arranged, high conductivity, nickel cooling rods that connect the silver furnace with the cooling ring. **Benefits:** This provides superior cooling performance over a wide temperature range. High cooling rates and instantaneous turnaround from heating to cooling are now achievable. Lower subambient temperatures and unmatched baseline performance can now be obtained with our range of cooling accessories in isothermal, programmed cooling, and MDSC® experiments. Turn-around time between experiments is dramatically reduced.

**Furnace**

The sample and reference platforms are surrounded by a high thermal conductivity, silver furnace, that uses rugged, long-life Platinel™ windings. Purge gases are accurately and precisely metered by mass flow controllers and uniformly heated to cell temperature, prior to introduction to the sample chamber. **Benefits:** The design provides a highly uniform thermal environment for the sample and reference. Precise temperature control algorithms deliver accurate isothermal temperatures, linear heating rates, rapid temperature response and the ability to heat at rates up to 200 °C / min. The rugged heater windings ensure long furnace life. Superior data quality results from the uniform purge gas flow.

Platinel™ is a trademark of Englehard Industries
AUTOSAMPLER

The patented DSC autosampler is a powerful performance and productivity enhancer for the Q Series™ DSC modules. It provides reliable, unattended operation of the Q1000 or Q100 DSC, even when using the RCS or LNCS cooling accessories. Its 50-sample, 5-reference pan carousel tray, enables research and analytical laboratories to analyze samples “around-the-clock.”

The sample arm controls loading and unloading of sample and reference pans in sequential or random order. An optical sensor guides the sample arm, ensuring precise pan placement and automatic calibration of the system. Maximum productivity from the DSC autosampler is achieved when paired with our intelligent Advantage™ software, that permits pre-programmed analysis, comparison, and presentation of results.

*D.U.S. Patent No. 6,644,136; 6,652,015; 6,760,679; 6,823,278

DSC Sample Pans

TA Instruments offers a wide selection of sample pans to meet multiple standard and specialized applications. These include aluminum, alodined aluminum, coated aluminum, copper, gold, platinum, graphite and stainless steel. They can be used under a variety of temperature and pressure conditions. Samples can be run in the standard DSC mode in open pans, crimped or hermetically sealed pans / lids or in pressure capsules. Samples in open pans can also be run at controlled pressures using the PDSC Cell. All aluminum standard pans have the same temperature and pressure rating. General details of the pans are as follows:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Hermetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>Aluminum</td>
</tr>
<tr>
<td>-180 to 600</td>
<td>-180 to 600</td>
</tr>
<tr>
<td>Pressure</td>
<td>100 kPa</td>
</tr>
</tbody>
</table>
**Q10P Pressure DSC Module**

The Q10P is a dedicated pressure DSC system that provides heat flow measurements on pressure sensitive materials from -130 to 725 °C, at pressures from 1 Pa (0.01 torr) to 7 MPa (1,000 psi). The cell employs standard heat flux DSC technology and incorporates pressure control valves, a pressure gauge, and over-pressure protection. The pressure DSC cell is also an accessory for the Q1000 DSC and can be used as a standard cell from -180 to 725 °C.

**Photocalorimeter**

The Photocalorimeter Accessory (PCA), for the Q1000 and Q100 DSC, permits characterization of photocuring materials between -50 and 80 °C. UV/Visible light (250-600 nm) from a high pressure mercury source is transmitted to the sample chamber via an extended range, dual-liquid light guide with neutral density or band pass filters. Tzero™ technology permits direct measurement of light intensity. It also provides for simultaneous measurement of two samples. The PCA can also be equipped with a dual quartz light guide for operation up to 250 °C.

**Mass Flow Controllers**

High quality DSC experiments require precise purge gas flow rates, especially when using high conductivity gases, such as helium. Mass flow controllers, along with integrated gas switching, provide flexible control as part of individual methods. Purge gas flow rates are settable from 0-240 mL/min in increments of 1 mL/min. The system is precalibrated for helium, nitrogen, air and oxygen and suitable calibration factors may be entered for other gases.
**Temperature Control Options**

**Refrigerated Cooling System**

The Refrigerated Cooling System (RCS) is frequently selected as the cooling device of choice for trouble-free, unattended DSC and MDSC™ operation. It operates from -90 °C to 550 °C using a two-stage, closed, evaporative refrigerator system. Because it is a sealed system requiring only electrical power, the RCS is frequently preferred for operation in areas where other refrigerants, such as liquid nitrogen, are difficult or expensive to obtain. The RCS is compatible with Q1000, Q100, and Q10 DSC modules.

**Liquid Nitrogen Cooling System**

The Liquid Nitrogen Cooling System (LNCS) provides the highest performance and greatest flexibility in cooling. It has the lowest operational temperature (to -180 °C), greatest cooling rate capacity (to 140 °C/min), and an upper temperature limit of 550 °C. It is ideal for isothermal crystallization studies. The LNCS uses liquid nitrogen efficiently, thus reducing operating costs. Its autofill capability allows the LNCS to be automatically refilled from a larger liquid nitrogen source for continuous DSC operation. The LNCS is available for the Q1000, Q100, and Q10 DSC modules.
**Finned Air Cooling System**

The Finned Air Cooling System (FACS) is an innovative cooling accessory for the Q1000, Q100, and Q10 DSC modules that offers a cost-effective alternative to the refrigerated and liquid nitrogen cooling systems. The FACS can be used for controlled cooling experiments, thermal cycling studies, and to improve sample turnaround time. It uses compressed air to cool the DSC cell. Stable baselines and linear heating and cooling rates can be achieved between ambient and 725 °C. A special version of the Quench Cooling Accessory is available for use with the FACS to speed cooling of the DSC cell to ambient temperatures.

**Quench Cooling Accessory**

The Quench Cooling Accessory (QCA) is a manually operated cooling accessory that is a cost-effective alternative to the automated RCS or LNCS. Its primary use is with the Q10 DSC to quench cool a sample to a subambient temperature prior to heating to an upper limit. Since active cooling is not present in QCA experiments, the T1 signal is the measured entity. The recommended temperature of operation of the QCA is from –180 to 400 °C. The QCA reservoir is easily filled with ice water, liquid nitrogen, dry ice, or other cooling mixtures.
Tzero™ Technology Provides:

- Essentially flat baselines with better than an order of magnitude improvement on other designs, especially in the subambient temperature range
- Superior sensitivity due to flatter baselines and better signal-to-noise ratio
- Best available resolution (even over power compensation devices)
- Faster MDSC® experiments
- Direct measurement of heat capacity (Q1000)

Tzero* technology produces the truest available representation of heat flowing to and from a sample, by removing instrumental thermal effects that degrade baseline flatness, sensitivity, and resolution in other designs. The Tzero cell's unique internal reference temperature sensor and electronic circuitry measure the resistive and capacitive imbalances that cause these effects. An advanced four-term, heat flow expression accounts for them, and also for known heating rate differences at the sample and reference that occur during major thermal events (e.g., melting). Tzero technology is available on the Q1000 & Q100. Advanced Tzero (available only on the Q1000) compensates for pan contact resistance, thereby further improving resolution and allowing direct heat capacity (Cp) measurements.

*U.S. Patent No. 6,431,747; 6,488,406; 6,523,998
**Baseline Stability (Flatness)**

Figure 1 shows a comparison of a Q1000 empty cell baseline with that from a high performance, non-Tzero, heat flux DSC. The data shows that the Q1000 baseline is superior in every way. The start-up offset is much smaller, the baseline is dramatically straighter, and the slope is greatly reduced. Notice the heat flow scale, and that the signal is almost zero throughout the -80 to 400 °C temperature range. This also contrasts markedly with results from other DSC designs, where a baseline bow of 1 mW over the same temperature range is often considered acceptable.

**Sensitivity**

Figure 2 shows a Q1000 high sensitivity glass transition (Tg) measurement, as a function of heating rate, for a very small (1 mg) sample of polypropylene, whose Tg is not easily measured by DSC, even with a larger sample, due to its highly crystalline nature. The data shows that the Tg is easily detected even at a slow 5 °C/min heating rate. The excellent Q1000 baseline is the essential key for accurate measurements of glass transitions and heat capacity from materials that exhibit weak and broad transitions.

**Resolution**

Figure 3 shows a comparative resolution plot of indium performed on the Q Series DSC’s (Q1000, Q100, and Q10) under identical conditions. The Q10 data is typical of a good performing DSC system without Tzero™ technology. The improvements seen in the Q1000 and Q100 are impressive displays of the power of Tzero™ technology in the steeper leading edge trace and in the subsequent faster return to baseline. This is especially true in the Q1000, which outperforms power-compensated DSC models in recognized resolution tests.
**MDSC® Technology Provides:**

- Separation of complex transitions into more easily interpreted components
- Increased sensitivity for detecting weak transitions and melts
- Increased resolution without loss of sensitivity
- Direct measurement of heat capacity
- More accurate measurement of crystallinity

In MDSC®, a sinusoidal temperature oscillation is overlaid on the traditional linear ramp. The net effect is that heat flow can be measured simultaneously with changes in heat capacity. Using Fourier transformation, the heat flow generated is separated in real time into a heat capacity component and a kinetic component. In MDSC, the DSC heat flow is called the Total Heat Flow, the heat capacity component is the Reversing Heat Flow, and the kinetic component is the Nonreversing Heat Flow. The Total Heat Flow signal contains the sum of all thermal transitions, just as in standard DSC. The Reversing signal contains glass transition and melting transitions, while the Nonreversing Heat Flow contains kinetic events like curing, volatilization, melting, and decomposition. The Q1000 uniquely permits increased MDSC productivity of high quality data by its ability to operate at standard DSC heating rates (e.g., 10 °C/min.).

*U.S. Patent Nos. 5,224,775; 5,248,199; 5,346,306
**Separation of Complex Transitions**

Figure 4 shows MDSC® results for a copolymer of polyethylene terephthalate and acrylonitrile/butadiene/styrene (PET/ABS) when analyzed over the temperature range from ambient to 170 °C. The MDSC total heat flow signal shows only the PET glass transition and cold crystallization, with no evidence of the ABS. The reversing heat flow clearly identifies glass transitions for both PET and ABS. The nonreversing trace indicates the cold crystallization peak for PET, plus an enthalpic relaxation resulting from the sample’s previous history.

**Improved Signal Sensitivity**

Figure 5 shows the improved sensitivity of MDSC for measuring very broad and weak transitions, such as glass transitions in highly crystalline polymers or where the Tg is hidden beneath a second overlapping thermal event. This data was generated using a very small (2.2 mg) sample of a polymer coating. The total heat flow shows no transitions in the region where a Tg would be expected, though the large endotherm around 40 °C indicates solvent loss. The Reversing Heat Flow does indicate a very weak (8.5 µW) Tg around 109 °C, illustrating the sensitivity of the MDSC technique.

**Improved Data Interpretation**

Figure 6 shows an application of interest in studies of foods or pharmaceuticals, in which the MDSC total heat flow signal and its reversing and non-reversing components are displayed for a 40% aqueous sucrose sample. While the former is not easy to interpret, the reversing signal clearly indicates a Tg for sucrose between -43.6 and -39.4 °C. The exothermic non-reversing signal (peak max -36 °C; heat of crystallization 5.7 J/g) relates to crystallization of free water that could not crystallize during quench cooling of the sample due to a significant increase in mobility and diffusion of the material at the glass transition.
DSC APPLICATIONS

Transition Temperatures
DSC provides rapid and precise determinations of transition temperatures using minimum amounts of a sample. Common temperature measurements include the following:

- Melting
- Polymorphic Transition
- Oxidation Onset
- Solid-Solid Transition
- Crystallization
- Thermal Stability
- Protein Denaturation
- Glass Transition
- Liquid Crystal
- Cure Onset

Figure 7 shows typical shapes for the main transitions observed in DSC.

Heat Flow
The DSC heat flow signal is commonly used to measure the following:

- Specific Heat Capacity
- Hazard Potential
- Lifetime Estimation
- Glass Transition
- Cure Rates
- Kinetics

Figure 8 shows a single analysis measurement of total heat and heat capacity (Cp) by advanced DSC technology (see page 12). The heat capacity increases as the sample passes through its glass transition, cold crystallization, and melting events.

Enthalpy
Heat flow signal integration gives quantitative enthalpy information about the transition. For example:

- Heat of Fusion
- Percent Crystallinity
- Heat of Crystallization
- Explosion Potential
- Degree of Cure
- Heat of Reaction

Figure 9 The DSC plot of a thermosetting resin allows determination of the heat of reaction and degree of cure. Specialty kinetics software can also provide the reaction order, activation energy, and reaction rates.
**TIME**

Kinetics is the study of the effects of time and temperature on a reaction. Common ASTM test methods include reaction induction time (E2046), oxidation induction time (OIT, D3895), and constant temperature stability (E487). Comparative OIT tests permit relative ranking of the effectiveness of different anti-oxidant packages in a given polymer. As seen in Figure 10, the analyses are rapid, and with relative performance quickly established, the antioxidant selection can be made on needs, processing conditions, and relative cost.

**PRESSURE (AND TIME)**

Pressure DSC accelerates OIT analyses and “sharpens” the onset of the oxidation process. Figure 11 shows a comparative study of a series of two component polymer dispersions containing different levels of the same antioxidant. Clear performance differences are readily seen. The tests provided the same answer in under two days that took up to two months of traditional “field exposure” to obtain. Other common PDSC applications include a) thermoset resin cures, b) catalyst studies, and c) micro-scale simulations of chemical reactions.

**PHOTOCURING**

The Photocalorimeter Accessory (PCA) provides a convenient tool to assess reactions initiated with UV/Visible light. Figure 12 compares two different acrylic formulations under the same conditions. The data shows that formulation A cures rapidly upon exposure to UV radiation, while formulation B reacts slower, and has both a longer time-to-peak and lower energy. In all PCA experiments, the peak shapes and transition energies are affected by the formulation chemistry, additives, initiators, and the purge gas used.