THERMOGRAVIMETRIC ANALYZERS
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 2000 procedures in our New Castle, DE (USA) or our Leatherhead, 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.
Sensitive, precise, rugged and automated are words that describe a TA Instruments Thermogravimetric Analyzer (TGA). The Q500, Q50, and Q600 are fourth generation products from the world leader in thermogravimetric analysis. Each represents an unparalleled investment because it delivers outstanding performance, is designed with the customer in mind, and is backed by superior support that is the hallmark of our company.
The Q500 is our top-of-the-line, research-grade thermogravimetric analyzer. Its efficient low mass furnace, ultra-reliable thermobalance, unique purge gas system (with mass flow control), and advanced automation provide for superior TGA performance. The Q500 is an expandable system that is well equipped to handle TGA applications, from the routine to the most demanding.

The Q50 is a cost-effective, easy-to-use, general-purpose thermogravimetric analyzer with many of the basic features of the Q500. It offers performance superior to most research-grade models. With integral mass flow control and gas switching capability, the Q50 is ideal for laboratories that need a high quality TGA for standard applications.

The Q600 provides a true simultaneous measurement of weight change (TGA) and heat flow (DSC) on the same sample over the temperature range from ambient to 1500 °C. It also can operate as a dual sample TGA. The Q600 is rugged, reliable, easy-to-use, and provides research quality results on a broad range of samples.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Q500</th>
<th>Q50</th>
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<tbody>
<tr>
<td>Furnace - Low Mass</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>Furnace - EGA</td>
<td>Optional</td>
<td>Not Available</td>
</tr>
<tr>
<td>Touch-Screen Display</td>
<td>Included</td>
<td>Not Available</td>
</tr>
<tr>
<td>Mass Flow Controller with</td>
<td>Included</td>
<td>Included</td>
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<tr>
<td>automatic gas switching</td>
<td></td>
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<tr>
<td>Autosampler</td>
<td>Optional</td>
<td>Not Available</td>
</tr>
<tr>
<td>Hi-Res TGA™</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>Auto-Stepwise TGA</td>
<td>Included</td>
<td>Not Available</td>
</tr>
<tr>
<td>Modulated TGA™</td>
<td>Optional</td>
<td>Not Available</td>
</tr>
<tr>
<td>TGA/MS Operation</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>Ambient to 1000 °C</td>
<td>Ambient to 1000 °C</td>
</tr>
<tr>
<td>Isothermal Temperature Accuracy</td>
<td>± 1 °C</td>
<td>± 1 °C</td>
</tr>
<tr>
<td>Isothermal Temperature Precision</td>
<td>± 0.1 °C</td>
<td>± 0.1 °C</td>
</tr>
<tr>
<td>Continuous Weighing Capacity</td>
<td>1.0 g</td>
<td>1.0 g</td>
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<tr>
<td>Sensitivity</td>
<td>0.1 µg</td>
<td>0.1 µg</td>
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<tr>
<td>Weighing Precision</td>
<td>± 0.01%</td>
<td>± 0.01%</td>
</tr>
<tr>
<td>Temperature Calibration</td>
<td>Curie Point (1 to 5 points)</td>
<td></td>
</tr>
<tr>
<td>Heating Rate - Low Mass</td>
<td>0.1 to 100 °C/min</td>
<td></td>
</tr>
<tr>
<td>Heating Rate - EGA</td>
<td>0.1 to 50 °C/min</td>
<td></td>
</tr>
<tr>
<td>Furnace Cooling</td>
<td>Forced air 1000 °C to 50 °C &lt;12 min</td>
<td></td>
</tr>
<tr>
<td>Sample Pans</td>
<td>Platinum: 50 µL, 100 µL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alumina: 50 µL, 250 µL, 500 µL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aluminum: 100 µL</td>
<td></td>
</tr>
</tbody>
</table>
**Furnace Type**
Horizontal, Bifilar Wound

**Temperature Range**
Ambient to 1500 °C

**Temperature Calibration**
Metal Standards (1 to 5 Points)
- 0.1 to 100 °C/min
- 0.1 to 25 °C/min

**Heating rate – Ambient to 1000 °C**
0.1 to 100 °C/min

**Heating rate – Ambient to 1500 °C**
0.1 to 25 °C/min

**Auto-Stepwise TGA**
Included

**Thermocouples**
Platinum/Platinum-Rhodium (Type R)

**Furnace Cooling**
Forced Air (1500 to 50 °C in < 30 min)

**Sample Capacity**
200 mg (350 mg including sample holder)

**Balance Design**
Dual Beam Horizontal

**Balance Sensitivity**
0.1 µg

**Calorimetric Accuracy/Precision**
± 2% (based on metal standards)

**DTA Sensitivity**
0.001 °C

**Mass Flow Controller with Automatic Gas Switching**
Included

**Vacuum**
to 7 Pa (0.05 torr)

**Reactive Gas Capability**
Included – separate gas tube

**Sample Pans**
- Platinum: 40 µL, 110 µL
- Alumina: 40 µL, 90 µL

**Dual Sample TGA**
Included
The heart of a Q500/Q50 TGA is the accurate, and ultra-reliable, vertical thermobalance housed in a temperature controlled environment. It uses the field proven, null-balance principle, where an optically active servo loop maintains the balance arm in the horizontal reference (null) position by current regulation in a transducer coil. An infrared LED source and a matched photodiode pair detect beam movement, while a flag attached to the balance arm controls the amount of light reaching each photodiode. A sample weight change unbalances the beam, and the net photodiode output feeds a control program, which electrically “nulls” the balance. The current required is directly proportional to the weight change. The design permits automatic switching between the dual 0-200 mg/0-1 g weight ranges. Benefits: The design provides the best accuracy and precision in weight change detection from ambient to 1000 °C, low baseline drift, and smooth, reliable operation over the entire weight range.
**Furnace**

Our custom-designed furnace is the second key element of a Q Series 500/50 TGA. It features low mass, rugged heater windings, and proprietary heater control technology. **Benefits:** Include rapid, accurate, and precise temperature programming over a wide range, plus optimized use in the Q500 of advanced techniques such as Hi-Res™ TGA and Modulated TGA™. Our reliable, long-life furnaces also increase the value of your investment.

**Purge Gas System**

A high efficiency, horizontal purge gas system has been expertly integrated into our unique thermobalance/furnace design. The purge gas, which is accurately metered by digital mass flow controllers, enters the furnace and flows directly across the sample. A portion of the purge gas is also diverted through the balance chamber, and the combined gases exit the system via a side arm that can be readily connected to a MS or FTIR. **Benefits:** Design minimizes buoyancy effects, and is superior to other vertical balance designs in removing decomposition products from the sample area. The digital mass flow controllers improve data quality.

**Temperature Control and Measurement**

Our unique, custom-designed system features a single control/sample thermocouple positioned immediately adjacent to the sample. A second thermocouple is located in the same sleeve slightly above the principal one. **Benefits:** Simultaneous heating rate control and sample temperature measurement are accurately and precisely accomplished. This innovative “control and feedback” design enables the system controller to program and maintain the temperature environment and heating rate selected by the operator. The second thermocouple serves to automatically disable the furnace should the temperature difference between the thermocouples exceed a set value.
**THERMOBALANCE**

The Q600 has an accurate, and highly reliable, horizontal dual-balance mechanism that supports both DSC and TGA measurements. The sample balance monitors actual sample weight, while the reference balance is used to correct the TGA measurement for beam growth. **Benefits:** Design provides high sensitivity, accuracy, and precision in detecting very small weight changes (0.1µg). The dual-beam design results in less drift compared to single-beam designs, improving accuracy and precision. It also uniquely permits independent TGA measurements on two samples simultaneously.

**TEMPERATURE CONTROL AND MEASUREMENT**

A matched Platinum/Platinum-Rhodium thermocouple pair embedded in the ceramic beams provides direct sample, reference, and differential temperature measurement from ambient to 1500 °C. A five-point temperature calibration can be employed using high-purity metal standards. Sapphire is used to insure accurate DSC results. **Benefits:** Accurate and reproducible (to 0.001 °C) sample and reference temperature measurements ensure the most sensitive detection of thermal events. The dual-beam/dual-thermocouple design provides superior ∆T accuracy compared to single-beam designs that locate the reference thermocouple in the furnace. Calibration of the DSC signal using sapphire results in DSC baseline performance superior to competitive SDT instruments.
**Furnace**

A Q600 feature is the ultra-reliable operation of its rugged, bifilar-wound furnace, which moves horizontally on a motor-driven screw assembly. An air-cooling feature provides for automatic post-test cooling of the furnace. **Benefits:** Design allows for accurate and precise temperature programming over a wide range, with smooth automatic furnace opening/closing, easy sample loading, and rapid post-experiment furnace cool-down for increased analysis productivity.

**Purge Gas System**

The Q600 uses a field-proven, horizontal purge gas system with digital mass flow controllers and gas switching capability. Accurately metered purge gas flows horizontally through the furnace and directly across the sample and reference pans prior to exiting the analyzer. A separate Inconel® tube allows the use of reactive gases. The exit port can be directly connected, via an optional heated capillary tube, to a MS or FTIR. **Benefits:** Design provides better baselines, minimizes buoyancy effects, prevents back diffusion, and efficiently removes decomposition products from the sample area. The Inconel tube permits special experiments using oxidizing or reactive gases.

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**AUTOSAMPLER**

The Q500 Autosampler accessory is a programmable, multi-position sample carousel that allows automated analysis of up to 16 samples. All aspects of sample testing are automated and software controlled, including pan taring and loading, sample weighing, furnace movement, pan unloading, and furnace cooling. The autosampler has the flexibility to meet the needs of both research and QC laboratories. Autosampler productivity is maximized by our Thermal Advantage software, which permits pre-programmed analysis, comparison, and presentation of results.

**Evolved Gas Analysis (EGA) Furnace**

The rugged and reliable EGA is an optional, quartz-lined furnace for the Q500 or Q50. The liner is essentially chemically inert to products produced from decomposition of the sample, and its reduced internal volume ensures rapid exit of these materials from the sample chamber. These features make the EGA an ideal furnace for use in combined TGA/MS or TGA/FTIR studies.

TA Instruments offers a 300 amu bench-top, triple-filter, quadrupole mass spectrometer, and TGA module-specific interface kits. The latter contain a heated, quartz-lined, stainless-steel, capillary interface, and a mass spectral database. A variety of FTIR suppliers provide gas cells and interfaces for use with all our TGA modules.
Mass Flow Controller
(with automatic gas switching)

The mass flow controller permits accurate, reproducible purge gas metering. The benefit is consistently superior data quality over conventional flow control devices. The automatic gas switching capability employs low volume, high-speed valves to provide instantaneous purge gas switching. This provides rapid changes between inert and oxidizing atmospheres. Purge gas flow rates are stored data file signals.

Q500/Q50 and Q600 Sample Pans

Platinum (50 and 100 µl), aluminum (100 µl), and alumina pans (100, 250, and 500 µl) are available for use with the Q500 and Q50. The Q600 sample pans are available in platinum (40 and 110 µl) and alumina (40 and 90 µl). Platinum is recommended in most cases due to its inertness and ease of cleaning.
HIGH RESOLUTION TGA™ (Hi-Res™ TGA)

Hi-Res TGA* is a patented furnace control technology that produces significant improvements over standard TGA in the separation of closely occurring decomposition events. The Q500 design is ideal for this purpose, since it can precisely and rapidly control and measure sample temperature and monitor small weight changes. Control algorithms supplied with this option are constant reaction rate and dynamic rate. Each offers specific advantages in resolution, but the dynamic rate technique is simpler to use, requires less operator expertise, and generates high quality results faster than the other methods. This is particularly useful in analytical methods development. Auto-stepwise isothermal is a third high resolution technique, and is included as a standard feature on the Q50, Q500, and Q600.

MODULATED TGA™

MTGA** is another TA Instruments innovation that offers advantages for material decomposition kinetic studies. It uses the proprietary heater control technology developed for Hi-Res TGA and MDSC®. MTGA produces model-free kinetic data, and activation energy can be continuously calculated and studied as a function of time, temperature, and conversion. MTGA is easy-to-use, and provides the kinetic data needed to improve industrial process productivity.


**U.S. Patent No. 6,113,261 and 6,336,741
**High Resolution™ TGA**

**Figure 1** shows comparative decomposition profiles of a polyvinyl acetate performed by standard, stepwise isothermal (SWI), and dynamic TGA techniques. The superior resolution provided by the latter pair is obvious. While the SWI method provided the separation with highest resolution for this sample, the dynamic technique produced comparable results in a fraction of the time needed to develop the SWI method, and also provided the high-resolution analysis much faster than the standard TGA method.

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**High Resolution™ TGA**

**Figure 2** compares the decomposition profile plots of a polyurethane material by standard and by Hi-Res TGA. The resolution superiority of the Hi-Res technique is clearly evident in both the integral and first derivative signals. The latter signal is especially useful in defining the onset and end set of the individual weight loss segments, as well as indicating subtle events that help to provide a “fingerprint” of the sample under the analysis conditions.

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**Modulated TGA™**

**Figure 3** shows the results of a kinetic study of the effects of temperature on the decomposition of 60% ethylene vinyl acetate (EVA) by modulated TGA™ (MTGA™), a technique that provides kinetic information in a single, time-saving experiment. The plots quantitatively show the decomposition profile for the EVA and changes in activation energy as functions of temperature. The data clearly support the dual-step decomposition mechanism. MTGA also provides the ability to follow activation energy as a function of conversion, which is an indicator of the type of mechanism involved.
Thermogravimetric Analysis measures the amount and rate of change in the weight of a material as a function of temperature or time in a controlled atmosphere. It is widely used in both research and quality control laboratories. TGA is particularly useful for the following measurements:

- Thermal stability
- Decomposition kinetics
- Composition
- Estimated lifetime
- Oxidative stability
- Moisture and volatile contents

**Thermal Stability**

TGA is often used to determine sample thermal stability and to reveal weight-loss decomposition profiles. Figure 4 shows typical thermal profiles for some common polymers (PVC, PMMA, HDPE, PTFE, and PI). The information allows materials selection for end uses where stability at specific temperatures is required.

**Composition Analysis**

TGA is used to determine sample composition by measuring the weight of each component as it volatilizes or decomposes under controlled conditions of temperature, time, and atmosphere. Figure 5 shows quantitatively the differences in type, amount, and decomposition mechanism of the main polymers in three paint samples. More detailed examination of the profiles below 150 °C may reveal further information on the amount and possible nature of the carrier solvent (aqueous or oil) used in each paint.
**Volatile Analysis**

TGA determinations of absorbed, bound, or occluded moisture, and organic volatiles are important analyses for product performance and environmental acceptance. Analysis of an organic salt hydrate in nitrogen (Figure 6) shows a bound-water content of 9.6%, and two lower temperature weight losses of 3.6% and 2.3% respectively. These losses are likely due to moisture at the salt surface or held to it by weak attractive forces.

**Effect of Additives**

Figure 7 compares the decomposition profiles of a polycarbonate material with and without an added flame retardant. The flame retarded material consistently decomposed at a temperature about 20-25 °C lower than that of the unmodified sample. The former material also lost a greater percentage of weight than the standard material (e.g., 48% vs. 28%) at a given temperature (e.g., 460 °C) during the decomposition step. This indicates that flame-retardant additives accelerate the polycarbonate decomposition.

**Simultaneous DSC/TGA (SDT)**

Figure 8 shows simultaneous DSC and TGA data for a soda ash sample. The TGA curve quantitatively tracks the loss of water and the onset of a higher temperature vaporization process. The DSC signal quantitatively reveals transitions associated with the water loss and the high temperature melt.