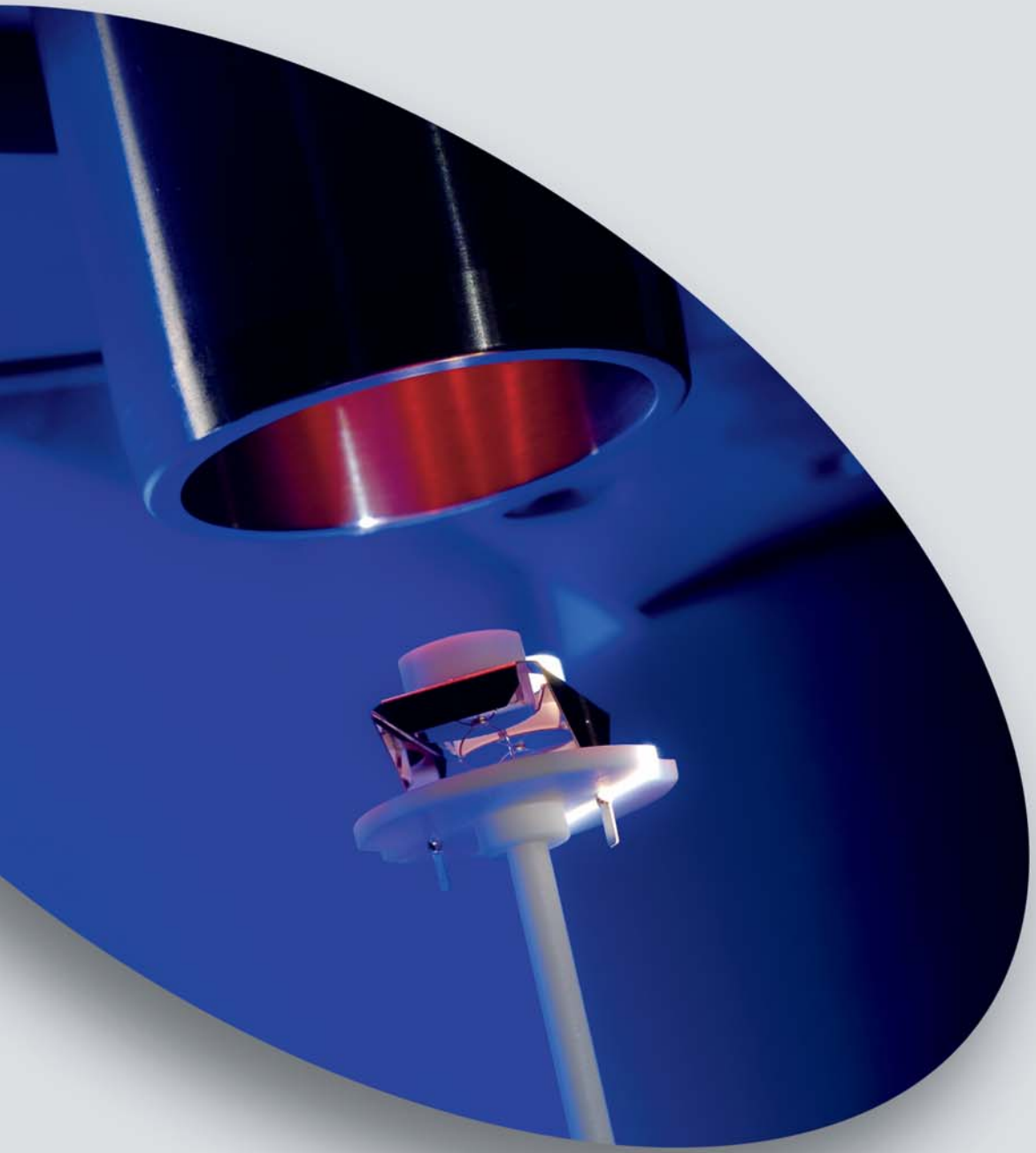
Differential Scanning Calorimetry

NETZSCH



DSC 404 *F3*

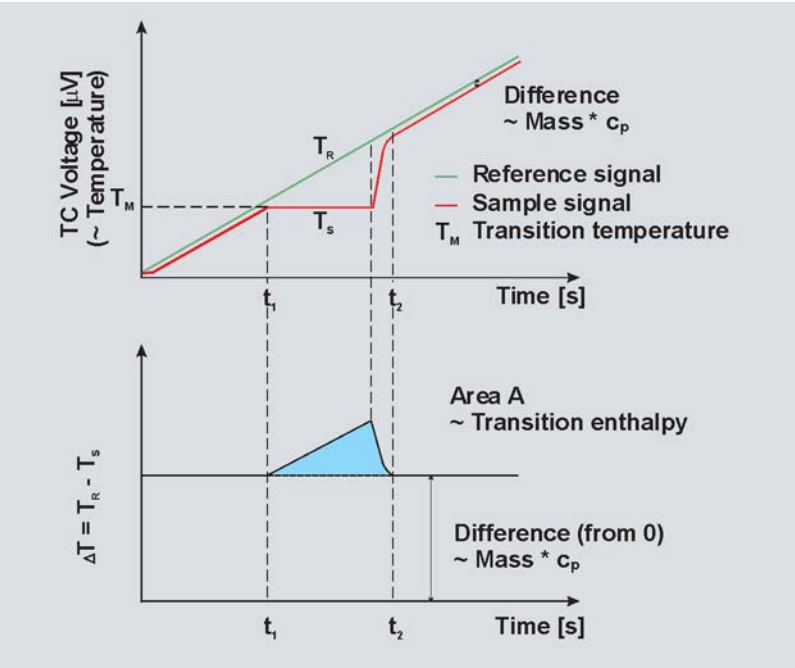
Pegasus®

Leading Thermal Analysis.

DSC 404 ***F3*** *Pegasus*® – Introduction to the Method

For over 45 years, NETZSCH Analyzing & Testing has been a leading manufacturer of high-performance thermal analysis systems – flexible, sophisticated and technically outstanding. Our customers' wishes and requirements are our guidelines. This, combined with experience and innovation, allows us to consistently set new benchmarks and standards in the field of thermal analysis instrumentation. Our success is a result of the creativity and enthusiasm of our engineers and scientists and our close cooperation with you as our customer.

Differential Scanning Calorimetry (DSC) is one of the most frequently employed Thermal Analysis methods. It can be used to analyze nearly all energetic effects occurring in a solid or liquid during thermal treatment. The NETZSCH DSC 404 ***F3*** *Pegasus*® operates according to the heat flux principle. Using this method, a sample and a reference are subjected to a controlled temperature program (heating, cooling or isothermal). The actual measured properties are the temperature of the sample and the temperature difference between sample and reference. From the raw data signals, the heat flow difference between sample and reference can be determined. The DSC 404 ***F3*** *Pegasus*® meets nearly all respective instrument and application standards, including: ISO 11357, ASTM E 967, ASTM E 968, ASTM E 793, ASTM D 3895, ASTM D 3417, ASTM D 3418, DIN 51004, DIN 51007, DIN 53765.



Signal generation in a heat flux DSC

Analysis possibilities:

- Melting/crystallization behavior
- Solid-solid transitions
- Polymorphism
- Degree of crystallinity
- Glass transitions
- Cross-linking reactions
- Oxidative stability
- Purity determination
- Specific heat
- *Thermokinetics*

Differential Scanning Calorimeter DSC 404 ***F3*** *Pegasus*®

The NETZSCH DSC 404 ***F3*** *Pegasus*® is a fast, reliable and cost effective tool for the determination of caloric effects (transformation temperatures and enthalpies). The vacuum tight system offers optimum performance from -150 to 2000°C using various interchangeable sensors and furnaces. The different optional vacuum pumps, gas flow control systems and sensors allow adjustment of the system to fit your applications in the field of quality control and failure analysis.

The DSC 404 ***F3*** *Pegasus*® is a compact, easy-to-operate system for high quality material characterization. The different interchangeable furnaces provide homogeneous heat flow from all sides to the DSC sensor placed in the center. The sensors combine optimum sensitivity, a short time constant and highly stable and reproducible baselines. Therefore, phase transition temperatures and enthalpy changes can be determined with unrivaled accuracy and reproducibility. The various DSC sensors offer true DSC performance over an unmatched temperature range (-150…1750°C). DTA sensors can be used up to the maximum service temperature of 2000°C.

The system is vacuum tight by design. Metal housed mass flow control systems, double furnace hoists and automatic sample changers for up to 20 samples are available as options. These, along with a great variety of crucible types, allow the system to accommodate nearly all possible materials and application ranges. The DSC 404 ***F3*** *Pegasus*® is the ideal foundation which can be optimized and adjusted to meet your needs, now or for future applications.

DSC 404 ***F3*** *Pegasus*® – Groundbreaking Technology

Vacuum tight design
– optimum atmosphere control

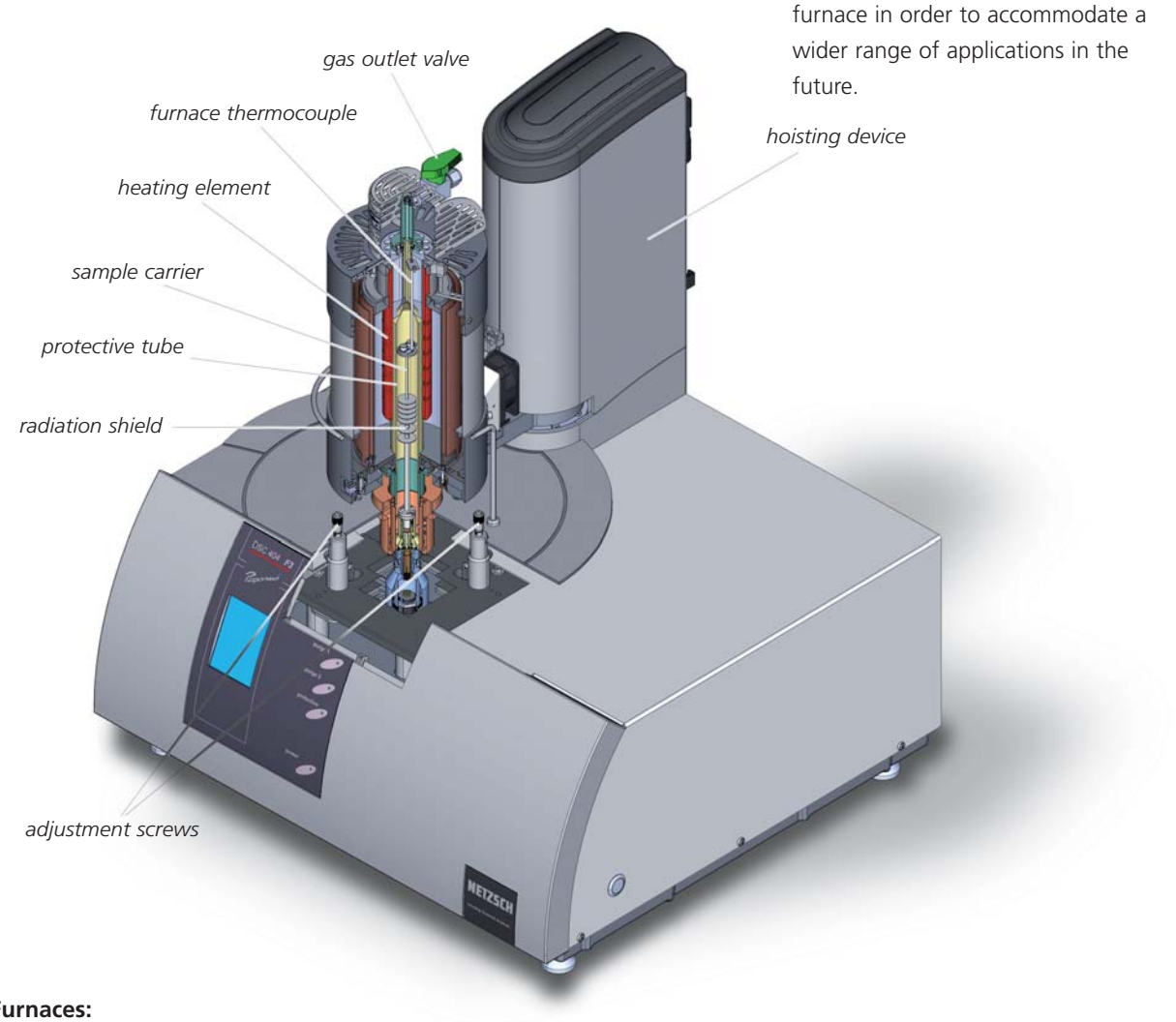
The DSC 404 ***F3*** *Pegasus*® is vacuum tight by design. Nearly all components are designed to fulfill the requirements of high purity gas applications. Diaphragm pumps can be used for pressures down to 4 mbar. Rotary pump systems allow pressures down to 10^{-2} mbar. The *Auto-Vac*® system supports automatic evacuation and backfilling with various purge gases.

Mass flow controllers

The purge or reactive gas flow is generally controlled via frits, manual control systems or tailor made mass flow control systems (MFC). The MFCs allow software-controlled gas switching and flow rates as well as recording of the actual gas flow by the software.

Various furnace systems

The DSC 404 ***F3*** *Pegasus*® can be equipped with a wide range of furnaces accommodating different temperature and application ranges. A double furnace hoist allows the simultaneous installation of two different furnaces for improved sample throughput and/or low- and high-temperature applications. The furnaces can easily be changed by the operator. It is also possible to upgrade the system with another furnace in order to accommodate a wider range of applications in the future.



Furnaces:

Furnace type	Temperature range	Cooling system
Steel furnace	-150 ... 1000°C	liquid nitrogen
Platinum furnace	RT ... 1500°C	forced air
Silicon carbide furnace	RT ... 1550°C	forced air
Rhodium furnace	RT ... 1650°C	forced air
Graphite furnace	RT ... 2000°C	tap water

Various sensors

The DSC 404 ***F3*** *Pegasus*® can be equipped with different sensor types. DTA sensors can, for example, be used for routine tests on aggressive sample substances. The DSC and DSC-c_p sensors are used for most tests and allow quantitative measurements of transformation enthalpies. The c_p versions additionally allow determination of the specific heat with high accuracy. Various thermocouple types allow optimum sensitivity and time constants in all temperature ranges. Sensors can be changed in less than a minute by the operator.

Unique sensor adjustment system

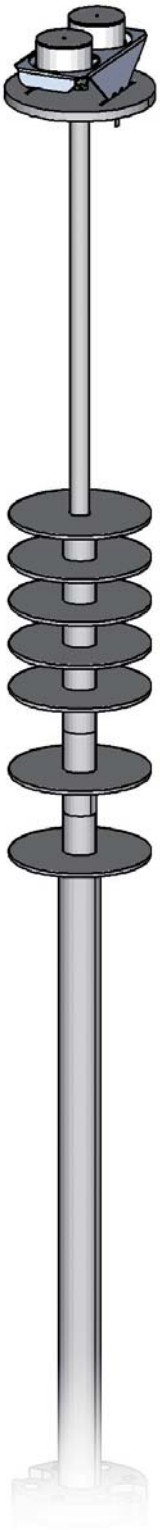
For optimizing the baseline, a micrometer adjustment system is integrated into the measurement part. The adjustment system allows placement of the sensor at the optimal position within the furnace. This guarantees a stable and reproducible baseline without major adjustment efforts.

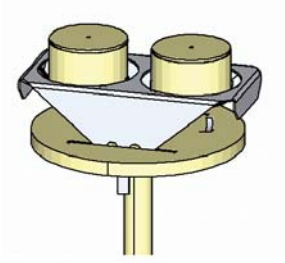
Automatic sample changer

An automatic sample changer for up to 20 samples is optionally available. The sample changer guarantees optimal crucible placement and maximum throughput. Preprogramming allows measurements to be carried out during the night or weekend. The software can automatically carry out analyses using predefined macros.

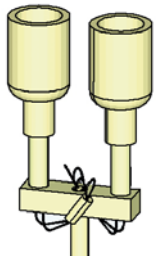
BeFlat® **and DSC correction**

Innovative software features such as *BeFlat*® and DSC correction allow for a fully automatic baseline correction as well as correction for system time constants and thermal resistances. These features can be optimized for your specific measurement conditions (crucible types, atmosphere, etc.). Furthermore, the true raw data signal can be accessed at any time.





DSC-c_p



DTA

Sensors:

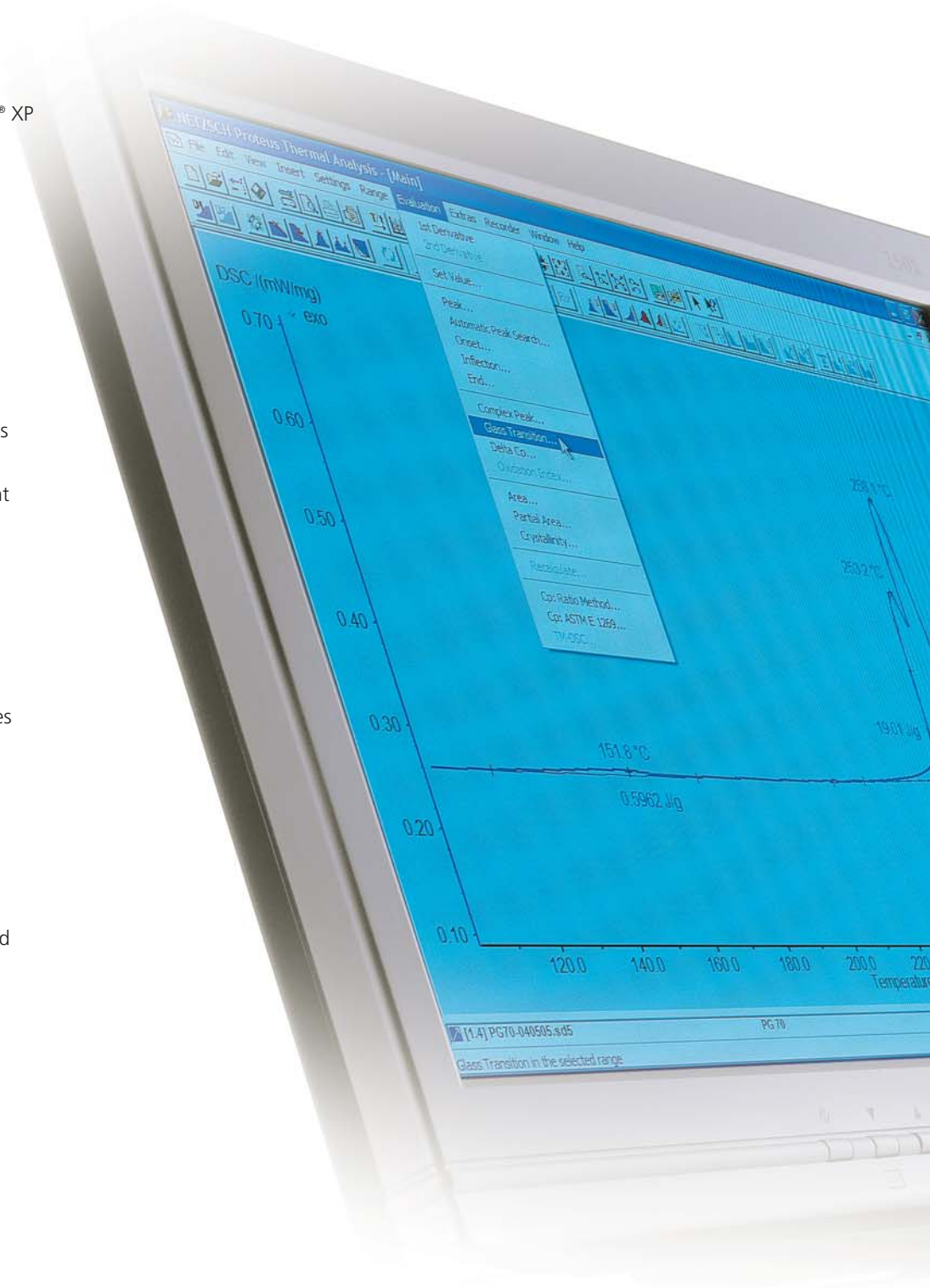
Sensor thermocouple	Temperature range	Sensor types	Atmospheres
Type E	-150 ... 700°C	DTA, DSC-c_p	inert, oxid. (to 500°C), vac.
Type K	-150 ... 800°C	DTA, DSC-c_p	inert, oxid. (to 600°C), red., vac.
Type S	RT ... 1650°C	DTA, DSC, DSC-c_p	inert, oxid., red., vac.
Type B	150 ... 1750°C	DTA, DSC	inert, oxid., red., vac.
Type W	RT ... 2000°C	DTA	inert, red., vac.

DSC 404 ***F3*** *Pegasus*® – *Proteus*® Software

The DSC 404 ***F3*** *Pegasus*® runs under a 32-bit Windows® software package which includes everything you need to carry out a measurement and evaluate the resulting data. Through the combination of easy-to-understand menus and automated routines, a tool has been created that is extremely user friendly and, at the same time, allows sophisticated analysis.

General Software Features:

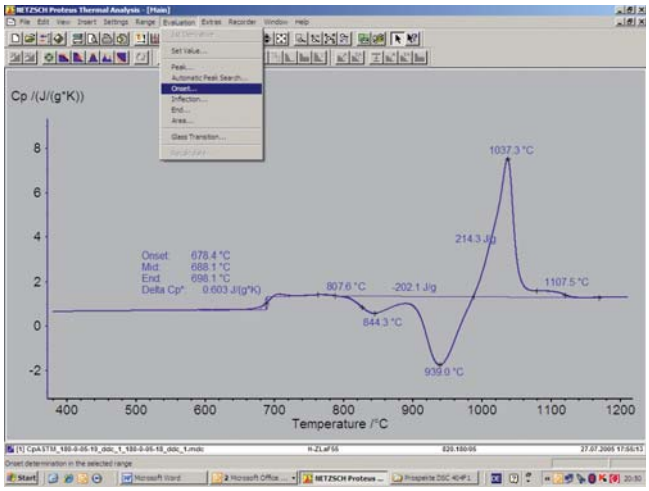
- Windows® software: for Windows® XP and Vista® (Enterprise, Business) operating systems
- Multi-tasking: simultaneous measurement and evaluation
- Multi-moduling: operation of different instruments with one computer
- Combined analysis: comparison and/or evaluation of DSC, TGA, DIL, TMA and DMA measurements in one plot
- Labeling: input and free placement of text elements
- Calculation of 1st and 2nd derivative
- Selectable scaling
- Graphic and data export
- Selectable colors and line types
- Storage and restoration of analyses
- Macro recorder (optional)
- Context-sensitive help system
- Temperature calibration
- Compatible with advanced software packages (Peak Separation, *Thermokinetics*)
- Software produced by ISO-certified company



Certified ISO 9001 by

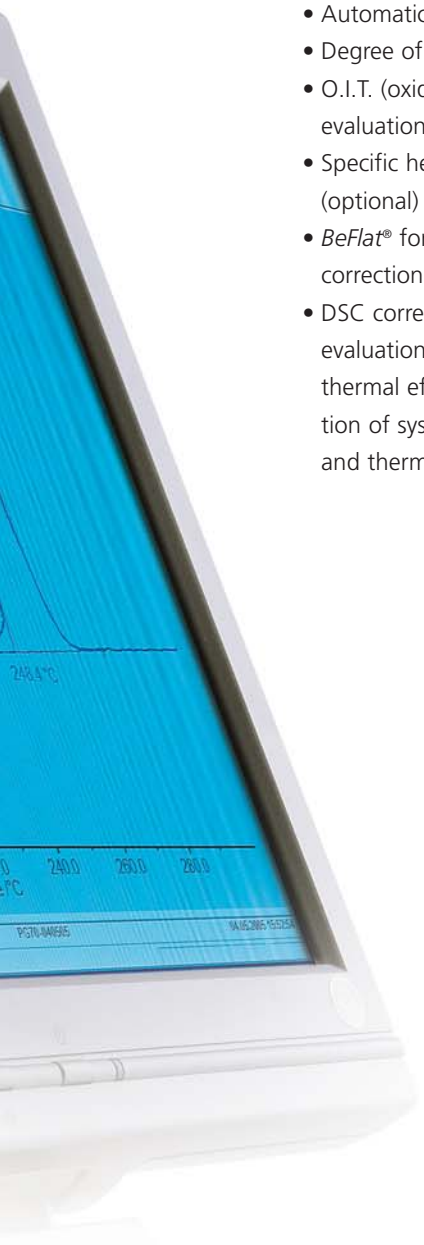
DSC Features:

- Determination of onset, peak, inflection and end temperatures
- Automatic peak search
- Transformation enthalpies: analysis of peak areas (enthalpies) with selectable baseline and partial peak area analysis
- Comprehensive glass transition analysis
- Automatic baseline correction
- Degree of crystallinity
- O.I.T. (oxidative induction time) evaluation
- Specific heat determination (optional)
- *BeFlat*® for automatic baseline correction (optional)
- DSC correction (optional): evaluation of exo- and endothermal effects under consideration of system time constants and thermal resistance values



Advanced Software (options)

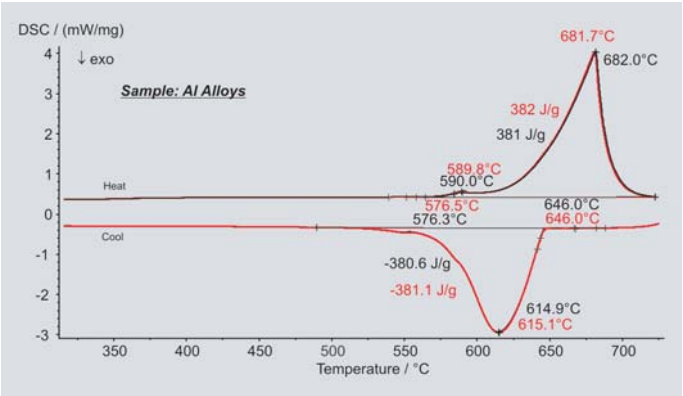
- Peak Separation Software: allows accurate separation and evaluation of overlapping transitions
- NETZSCH *Thermokinetics*: allows advanced characterization of reactions and kinetic parameters on the basis of multiple-step kinetic analysis on up to 16 curves, also provides predictions of the process
- Purity determination



DSC 404 ***F3*** *Pegasus*® – Applications

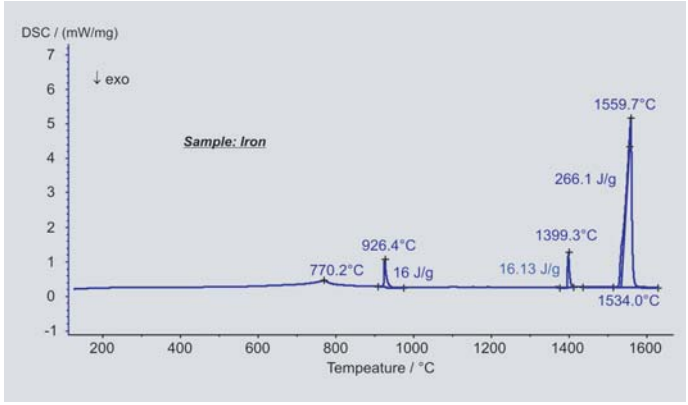
Reproducible testing of aluminum alloy

In this example, two different samples of the same aluminum alloy (Al-Mg-Si) were measured with the DSC 404 ***F3*** *Pegasus*® during heating and cooling. The melting and solidification of the alloy are clearly visible in the measurement results. The differences between the two samples, however, are minimal. The characteristic temperatures (onsets, peaks) all agree within 0.3 K. The differences between the peak areas are less than 1% for both heatings and coolings. The good agreement between the two measurement results demonstrates the excellent performance and reproducibility of the DSC 404 ***F3*** *Pegasus*®.



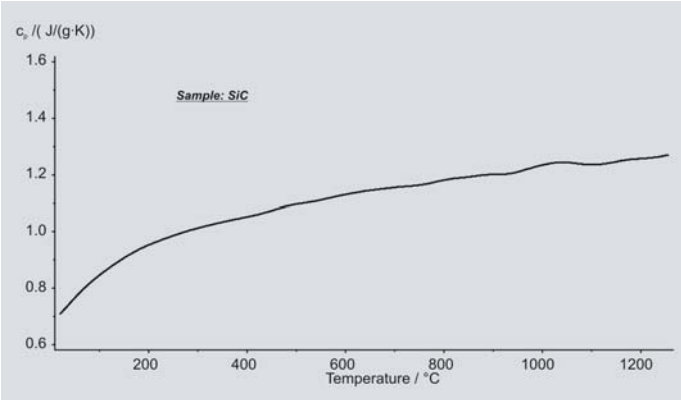
Phase transitions of iron

The specific heat flow rate of iron was measured between room temperature and 1620°C using a DSC 404 ***F3*** *Pegasus*® equipped with a Rhodium furnace. The peak at 770°C is due to a change in the magnetic properties of the material (the Curie transition). At peak temperatures of 926°C and 1399°C, two structural changes (changes in the crystal structure) occurred. Most likely due to impurities in the material, these temperatures are slightly shifted from the literature values for pure iron. Melting occurred at 1534°C (extrapolated onset). The heat of fusion was 266.1 J/g. This is less than a 1.5% deviation from typical literature values for pure iron.



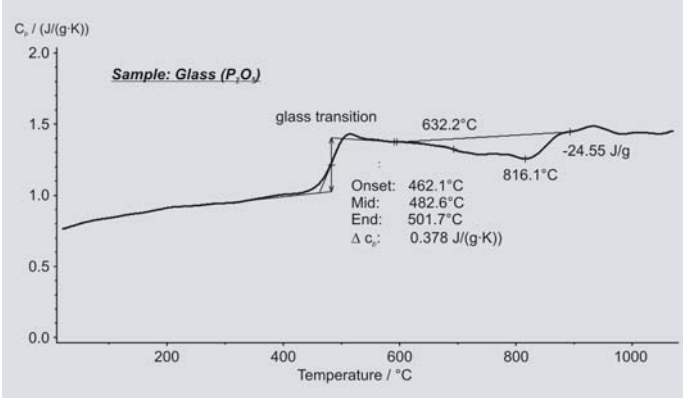
Specific heat of silicon carbide

Silicon carbide is used in numerous industrial applications. It is employed as a filter system in modern car exhaust systems and in the steel industry. It is used as a brake disk material and as a heating element in high-temperature furnaces. Presented here are the measurement results of a solid silicon carbide block measured up to 1200°C. It can clearly be seen that the increase in specific heat follows Debye's law very well. At the highest temperatures, the specific heat shows only a weak temperature dependence, as can be derived from the rule of Dulong and Petit.



Phosphate glass

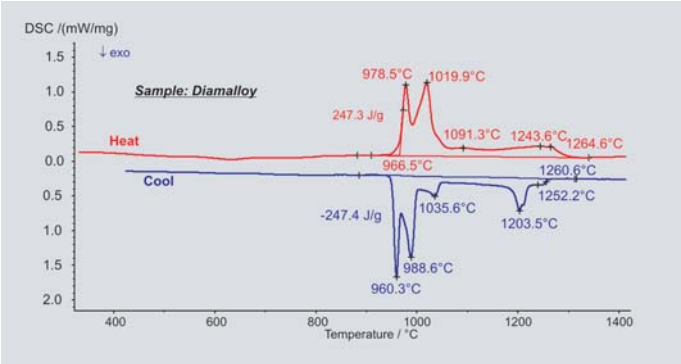
Here, a fine-grained phosphate glass powder was measured between room temperature and 1100°C. As is typical for such glass types, the glass transition was measured at 483°C (midpoint). At 632°C, an exothermal effect was recorded. This effect is most probably caused by structural changes in the material and/or agglomeration of the powder particles above the softening point. The large surface area of the powder is reduced, causing a slight energy release. The energy release is superimposed onto the true specific heat values between 600°C and 900°C.

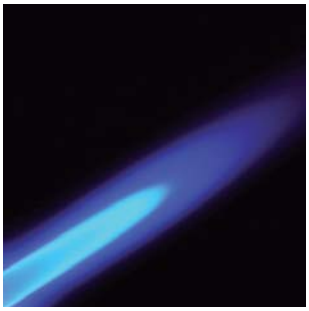


DSC 404 *F3 Pegasus*® – Applications

Diamalloy 2002

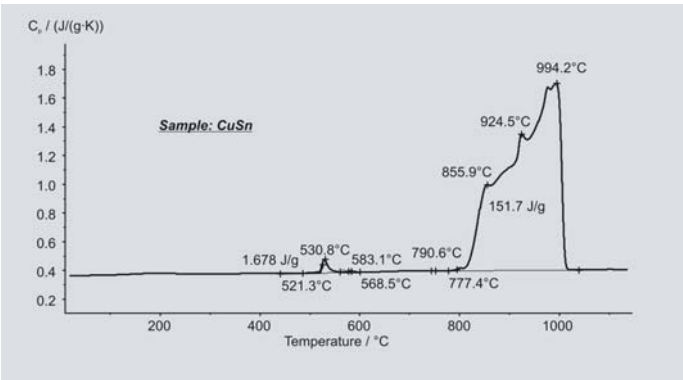
Diamalloy 2002 is a special alloy system containing tungsten carbide and a nickel-based alloy. Such alloys are often used as a powder in specialized coating processes (HVOF: high velocity oxy fuel processes). To optimize such processes for a specific powder, the melting and solidification range must be known. Presented here are measurements carried out during heating and cooling. As can be seen, melting starts at 966°C and covers a range of nearly 300 K. Above 1265°C, the material is fully molten. Solidification occurred at 1261°C during cooling. Due to the complex nature of such alloys, the processes of melting and solidification are quite sophisticated but can easily be analyzed by appropriate DSC tests.





Melting of bronze (CuSn)

Bronze is a copper-based alloy used since ancient times for the production of weapons, cans and other metal products. Nowadays, it is often used for bearings or spring components. Depending on the tin content and the amount of additives, the melting behavior of such alloys can change. The alloy analyzed here is generally utilized in infiltration processes. It shows solid-state phase transitions at 521°C and 568°C (onset temperatures). Melting started at 777°C. The mushy (semi-solid) region covers a range of more than 200 K. The material is fully molten above 994°C.



DSC 404 ***F3*** *Pegasus*® – Servicing Our Customers' Special Needs

Accessories

A wide range of crucibles (aluminum, silver, gold, copper, platinum, alumina, zirconia, graphite, stainless steel, etc.) is available for nearly all possible applications and materials.

For working in critical atmospheres, a "CO version" of the DSC 404 ***F3*** *Pegasus*® can be supplied. This version is optimized for measurements under corrosive or reducing atmospheres. Gas flow control systems are prepared in a separate box and special sensors with protected thermocouple wires are available.

For measurements on difficult samples or radioactive substances, the DSC 404 ***F3*** *Pegasus*® can be prepared for installation in a glove box or hot cell. Electronics are removed from the measurement part and all cables and fittings are prepared for connection to an existing feedthrough.

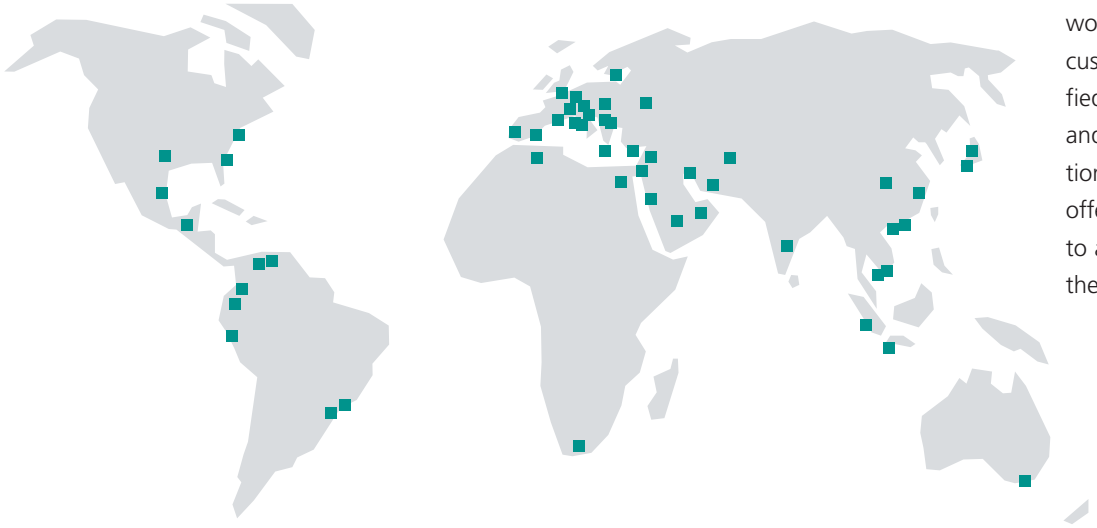
If you have any other special application or test condition, ask us! Our engineers are prepared to develop special versions of instrumentation or software with your requirements in mind.

Global Customer Support & Service Network

State-of-the-art technology combined with optimal customer support are NETZSCH trademarks. Our training department provides a complete range of programs tailored to the needs of our customers in research, education and industry.

A wide range of different seminars, users' meetings and individual training programs are available to assist you in achieving optimum performance and benefit from your thermal analysis system.

NETZSCH is the fastest growing company in the field of thermal analysis and thermophysical properties testing in the world. This can be attributed not only to our superior technology and quality, but also to our unmatched pre- and after-sales service network. NETZSCH-certified staff at 45 service centers across the world provide fast and reliable customer support including qualified installation, calibration services, and maintenance contracts. In addition, our applications laboratories offer contract testing and support to address the most specific of thermal analyses.



Pegasus®

Advantages in DSC Testing

The new DSC 404 ***F3*** *Pegasus*® is the ideal tool for day-to-day work in your laboratory. The system is generally employed for:

- Product development
- Quality assurance
- Failure analysis

The key features of the DSC 404 ***F3*** *Pegasus*® are:

- Maximum flexibility
- Top quality
- Easy to use
- Wide range of accessories
- Low cost of ownership

The DSC 404 ***F3*** *Pegasus*® is part of the NETZSCH high-temperature series of instruments. Together with the DIL 402 PC/C (dilatometer), the TMA 202/402 (thermomechanical analyzer), the DMA 242 C (dynamic mechanical analyzer), the STA 449 *Jupiter*® (simultaneous thermal analyzer), the DEA 230/231 series (dielectric analyzers) for cure monitoring, and other DSC and TGA systems, a fullscale thermal analysis of your materials and parts can be carried out.

NETZSCH offers a full range of low and high temperature thermal analysis instruments for temperatures between -260 and 2800°C, including all conventional thermal analysis systems.

For thermophysical properties testing (measurement of the thermal diffusivity/conductivity), NETZSCH offers a broad range of heat flow meters (HFM), guarded hot-plate systems (GHP), flash devices (LFA), and other thermal conductivity testers (TCT).

Technical specifications subject to change

Leading Thermal Analysis.

NGB · DSC 404 F3 · 1000 · 0308 · MMM

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