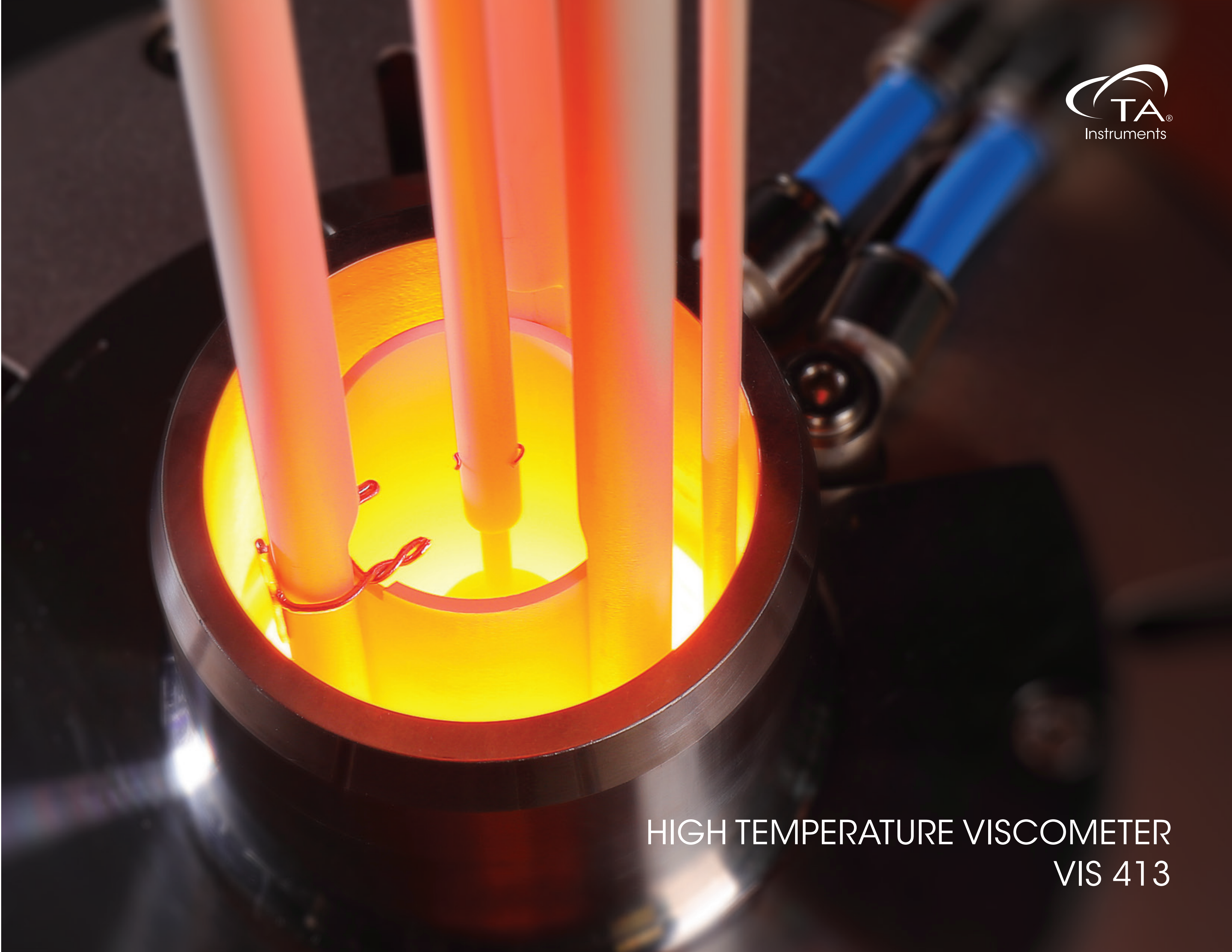
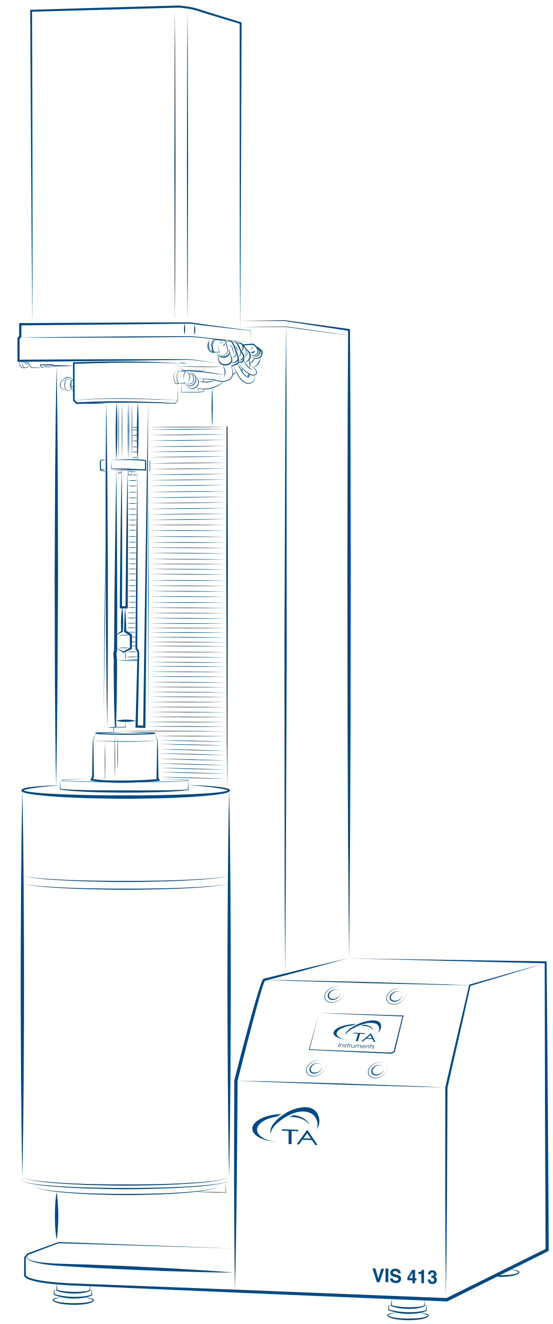


HIGH TEMPERATURE VISCOMETER
VIS 413

Discover the
rotational viscometer
with exclusive
Vacuum and
Reactive Atmosphere
capability for
Highest Temperature
melt viscosity measurements
on **Challenging Samples**



VIS 413 | HIGH TEMPERATURE ROTATIONAL VISCOMETER

TA Instruments invites you to experience the latest innovations in high temperature rotational viscometers, the VIS 413. The VIS 413 viscometer is designed for scientists who need to obtain melt viscosity data from the widest range of materials at the highest temperatures.

Advances in core measurement technology for rotational speed control and torque measurement enable viscosity measurements with superior precision. The viscometer sensor utilizing TA Instruments proprietary technology empowers you to measure in a wider viscosity range with a higher level of accuracy.

The new powerful, easy-to-use, and safe reaction atmosphere control system extends the applicability of the high temperature viscometer for measurements with air-sensitive materials. This allows you to replicate demanding environmental conditions, including vacuum, inert and reactive atmospheres.

TA instruments' vast experience with high-temperature furnace development and manufacture is used in the new viscometer furnace. As a result, the VIS 413 covers the largest temperature range and offers excellent temperature stability and homogeneity. The quality and unique performance of the furnace allows you to measure melt viscosity accurately in the widest temperature range.

The sophisticated water cooling system drastically reduces the cool-down time of the furnace and sensor, providing excellent viscosity measurement stability and safe operation. The minimized idle time doubles the productivity of the instrument and improves the output of your research.

Spring-loaded sample crucible holders at the viscometer sensor allow for simple and safe sample loading. The proven design and the small instrument footprint allow for installation and operation of the viscometer in a glovebox for reliably handling oxygen or moisture-sensitive samples.

Discover the advanced engineering and attention to detail that provides enhancements in every aspect of high temperature viscometer technology and application flexibility.

VIS 413 HIGH TEMPERATURE VISCOMETER

The HIGHEST TEMPERATURE and MOST VERSATILE VISCOMETER

TECHNOLOGY | HIGH TEMPERATURE ROTATIONAL VISCOMETER

The VIS 413 viscometer is equipped with the latest TA Instruments high-temperature furnace technology. Two water-cooled furnace configurations provide industry leading sample temperatures of up to 1750 °C. The integrated water cooling enables unparalleled short cool down times and doubles the productivity of the VIS 413 compared to other instruments in the market.

Backed by decades of experience in design and manufacture, the sophisticated high-temperature furnaces ensure excellent thermal stability, temperature homogeneity, and a long-lasting lifetime.

The improved vacuum-tight design of the instrument allows for complete evacuation of oxygen from the viscometer before and/or after an experiment. Vacuum capability is proven to remove oxygen and humidity much more efficiently than an inert purge. This feature provides purer testing atmospheres faster than a purge gas flow alone could. Viscosity measurements can be performed in inert (e.g. N_2, Ar) or reactive (e.g. H_2/N_2, CO/CO_2) atmospheres. These unique features allow measuring the viscosity under realistic environmental conditions and analyzing oxygen-sensitive sample materials, such as coal ash, metals or salts.

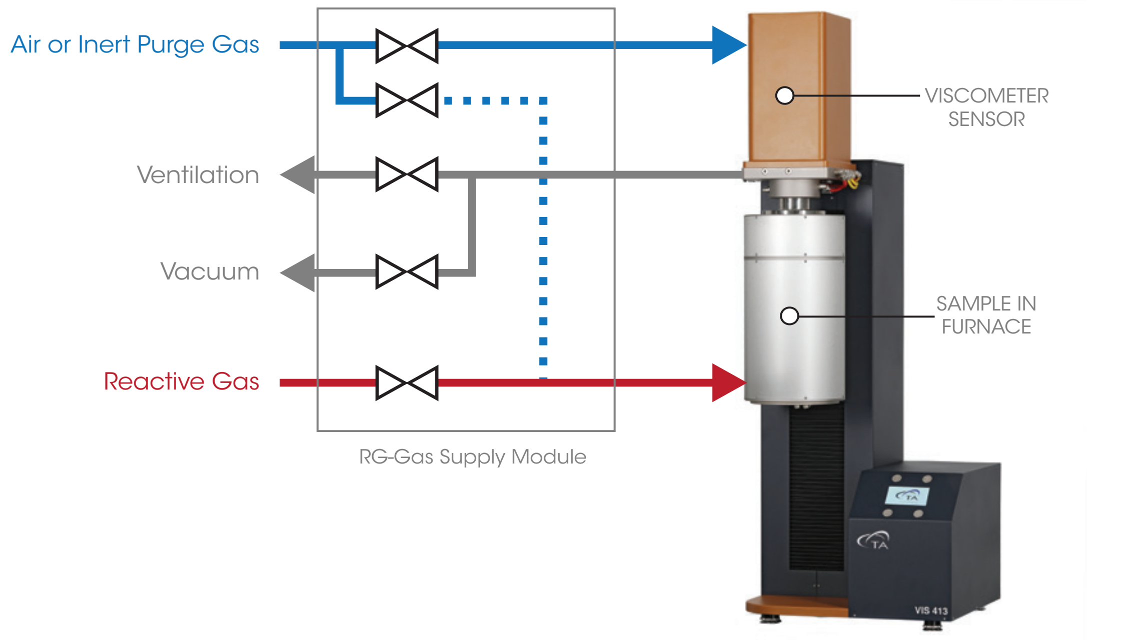
The vacuum-tight furnace design and dedicated gas flow paths in the instrument provide reliable ventilation of the reaction atmosphere through a single connection. This ensures the highest safety standards for experiments with potentially toxic gas atmospheres.

The new VIS 413 is a safe, accurate and flexible high-temperature viscometer for the analysis of all sample materials in air or controlled atmospheres.

The VIS 413 can be combined with a reactive gas supply module that allows for software-controlled evacuation and inert or reactive atmosphere control of the sample in the furnace.

The reactive gas-module provides unique operational benefits for obtaining viscometry measurements from challenging samples:

- Complete system evacuation provides improved atmosphere purity in less time compared to simply purging
- Mimic real process environment or reliably control measurement conditions
- Purge the viscometer sensor to prevent contamination when working with volatile samples
- Perform measurements in reducing atmospheres like CO/CO_2 and H_2/N_2 to provide absolutely oxygen-free atmospheres
- Controlled ventilation pathway ensures lab safety



PROPRIETARY FURNACE TECHNOLOGY PROVIDES the WIDEST TEMPERATURE RANGE and EXCLUSIVE VACUUM and REACTIVE ATMOSPHERE CAPABILITY

TECHNOLOGY
SAMPLE CRUCIBLE, ROTOR, HOLDERS

VIS 413 viscometers allow simple and safe sample loading. The sample crucible is held in position by spring-loaded ceramic fixtures. Even if the viscometer is located in a fume hood or a glove box sample loading is easy and convenient.

Sample crucibles and rotors are available in ceramics and platinum alloy. Interchangeability of the measuring systems provides the right material choice for every sample material and customer requirement. In the table below the measuring system materials are compared.

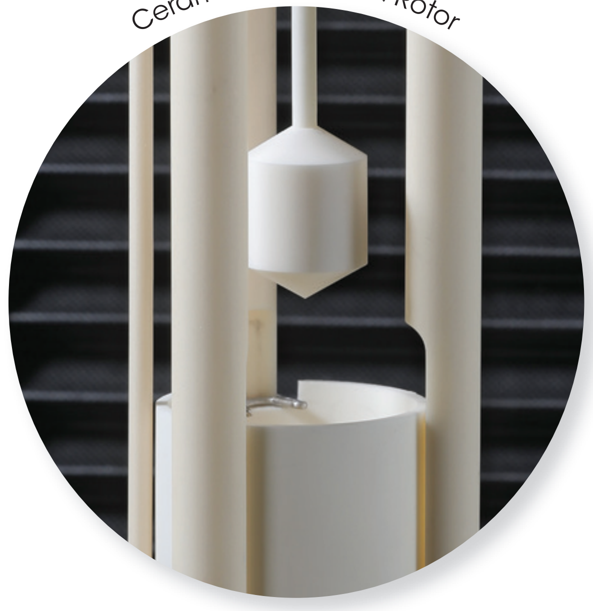
	Pt-Alloy	Ceramics
Type of use	Re-useable Typically cleaned by heat and acid treatment	Disposable No cleaning required
Usually applied for	Glass, Enamel, Casting Powder	Ash, Slag, Magma, Metals

The practical geometry of the sample crucible and the universal rotor coupling allows us to offer customized sample crucibles and rotors made of different materials to meet individual customer requirements.

The well-thought-out design and accessories of the VIS 413 enable flexible configuration and trouble-free operation for viscosity measurements of all sample materials in air or controlled atmospheres.

EASE OF SAMPLE HANDLING
through **FIELD-PROVEN DESIGN** with the right
CHOICE of **MEASURING SYSTEMS**
for each **SAMPLE MATERIAL**

Ceramic Crucible & Rotor



Metal Crucible & Rotor

Ceramics / Metal Crucible & Rotor

TECHNOLOGY | VISCOMETER

A proprietary frictionless and wear-free EC motor is the heart of the VIS 413 viscometer sensor. In combination with the digital optical encoder, the most accurate rotational speed measurement and control is realized.

Optimal alignment of the rotor with lowest reproducible friction is provided by sealed high-precision ball bearings. Compared to an air bearing, the main advantage is the ability to operate in vacuum. This is a tremendous improvement for high-temperature viscosity measurements in controlled atmospheres.

The gas dosing accessory provides a purge gas flow protecting the EC motor, optical encoder and the ball bearings. This feature allows viscosity measurements on volatile sample materials to be performed which otherwise could contaminate the viscometer sensor.

The proprietary EC motor-based torque sensor delivers the most accurate high-temperature viscosity data, even on challenging sample materials under the widest temperature range, and under application-relevant controlled atmospheres.

Technical Specifications

	VIS 413	VIS 413HT
Viscosity Range	10^1 – 10^8 dPa s	
Sample Temperature Range	Up to 1550 °C	Up to 1750 °C
Atmosphere	Air, Vacuum, Inert, Reactive	
Rotor Diameters	12 mm / 16 mm	
Sample Volume	26 ml	
Rotor and Sample Crucible Materials	Pt-alloy, Al_2O_3, other on request	
Rotational Speed	0.001 – 300 min^{-1}	
Compliant Standards	ISO 7884-2, ASTM C965, ASTM C1276	
Dimensions W x D	555 mm x 600 mm	

ROBUST PROPRIETARY RHEOMETER provides **VACUUM CAPABILITY** for **HIGH TEMPERATURE** viscosity measurements on **CHALLENGING SAMPLES**

Viscosity of Melts at High Temperatures

Processing melts at high temperatures is the basis for the industrial manufacture of many products, including glasses and metals, or for reliably operating industrial incineration plants by continuously removing slag. In addition to temperature, the melt viscosity of materials is significantly influenced by their chemical composition and ambient conditions such as atmosphere. For industrial processing of molds, the viscosity is an essential parameter that determines the economy of the processes and the quality of the products.

Glass Industry

Processing molten glass is part of the industrial manufacture of glass products, such as float glass, glass fibers and frits.

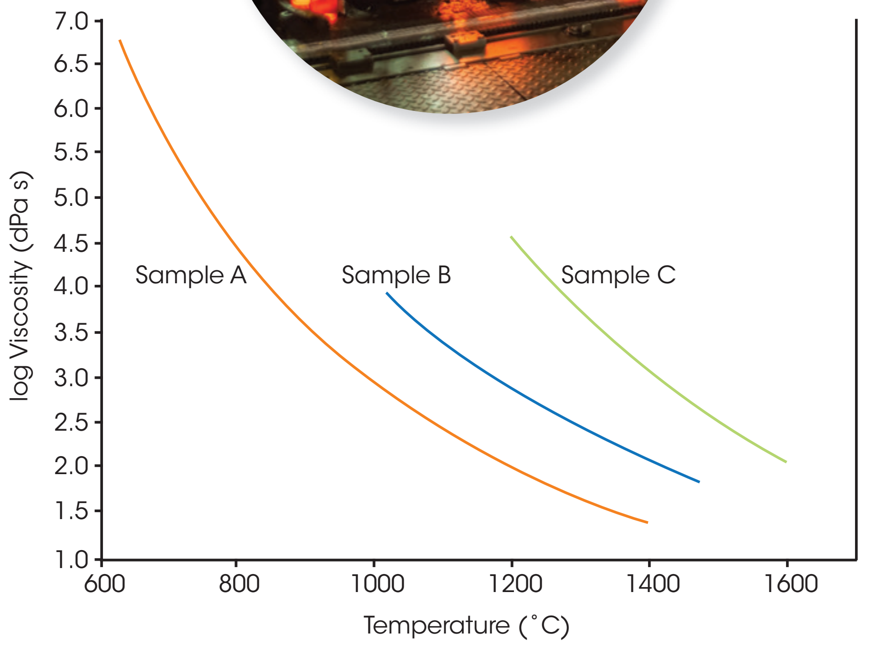
Glass and Enamel Viscosity

The viscosity of a glass affects the temperature ranges within which the glass can be worked. Measuring the temperature-viscosity relationship is essential to determining the correct melting and heat treatment regimes in glass production and processing.

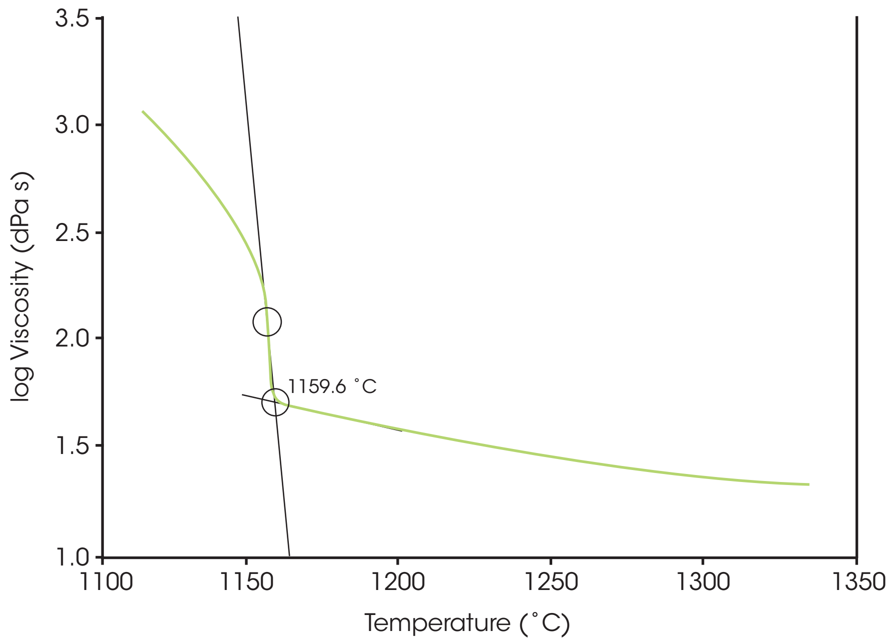
For example, viscosity directly affects the homogenization of a melt and removal of air bubbles. It enables manufacturers to predict and model how the glass will perform in a forming process or glass fiber generation.

Glass viscosity varies inversely with temperature. As it is heated, viscosity decreases and the glass flows more easily. The relationship between temperature and viscosity is linked directly to the chemical composition of a glass. Manufacturers need techniques to measure and model this relationship for a range of glass compositions and temperatures.

The viscosities of most glasses are typically measured between 700 °C and 1600 °C. In the diagram on the right the results of high temperature viscosity measurements of three glasses by a VIS 413 are plotted over temperature.



Viscosity data of three glasses in the temperature range between 600 °C and 1600 °C measured with VIS 413.



Viscosity of a casting powder as function of temperature

Metal Industry

Handling of molten metals is part of traditional and additive manufacturing processes. Additives like casting powders are essential for providing high-quality metal products.

Metals

Molten metal flows occur in traditional and continuous casting processes, in additive manufacturing and in soldering and welding applications. The elementary property required to understand, predict and improve these flows is the viscosity of the molten metal.

Molten metals are generally highly reactive with oxygen. The unique vacuum and reactive gas capability of the VIS 413 allows performing measurements in reducing atmospheres, such as forming gas (H_2-N_2 mixture), avoiding metal oxidation even at the highest temperatures.

Casting Powder

Casting powders are essential for continuous casting processes. The main function of the glassy casting powders is to provide lubrication between the solidifying metal and the water-cooled copper mold. The casting powder is continuously added on top of the mold, covering the free surface of the liquid steel. The powder layer in contact with the liquid steel melts and infiltrates into the gap between the steel shell and the copper mold wall and provides lubrication. The lubrication depends on the viscosity of the melted casting powder. The values must be adjusted to provide a minimum friction. Therefore, for industrial applications the viscosity values of casting powder at temperatures between 1200 °C and 1400 °C are considered to be relevant.

The diagram on the left presents the temperature-dependent viscosity of a casting powder measured with the VIS 413. Typical for mould powders is the beginning of crystallization at a defined temperature – in this case 1160 °C.

VIS 413 | APPLICATIONS

Energy Industry

The viscosity of melts at high temperatures is critical for efficiency, safety and reliability of energy conversion processes. In traditional coal-fired power plants and gasifiers for converting solid fuels into syngas, slag and ash must flow down the wall of the boiler. In emerging new power generation techniques molten metals and salts are considered for cooling and heat transfer purposes.

Coal Ash / Slag

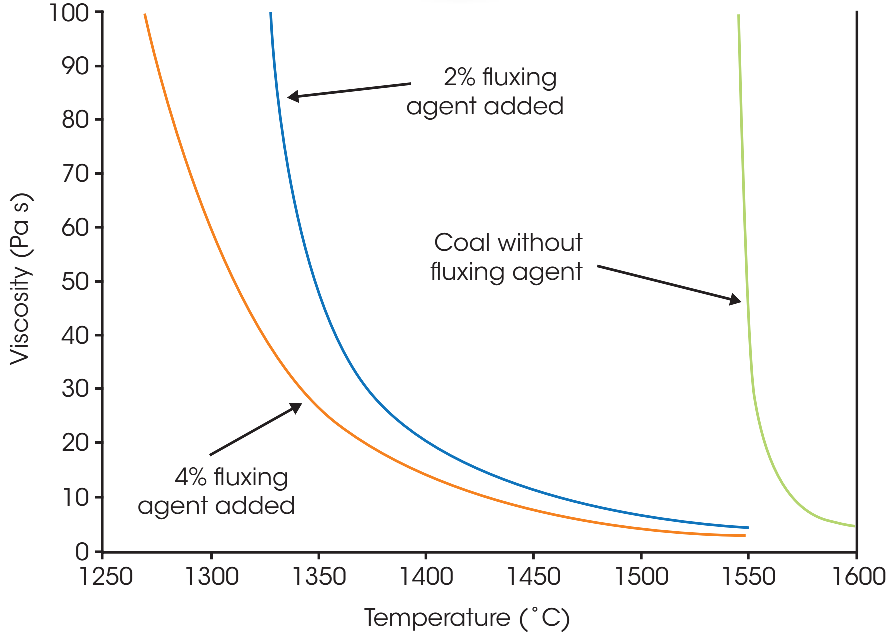
In coal-fired power plants, coal gasification plants, and waste incineration plants, ash and slag must be removed from the boiler. As feedstock is continuously supplied the slag must be continuously removed from the process. The best way to achieve this is to let the molten slag flow into a quenching bath from which it can be retracted. The viscosity of the slag must be low enough to let it flow down the lining of the boiler without causing deposits. The slag viscosity can be adjusted by adding fluxing agents. For proper dosing of fluxing agents the slag viscosity of the used feedstock must be measured under boiler operation conditions.

Slag viscosity measurements must be performed under similar atmospheric conditions as in the boiler. The VIS 413 can perform measurements under controlled CO/CO_2 mixture atmospheres as suggested for coal slag viscosity determination.

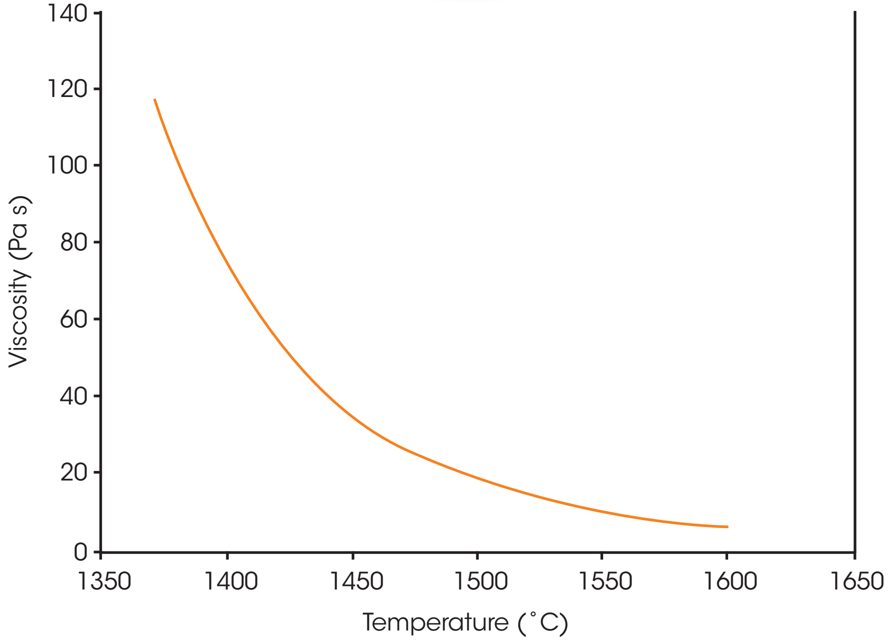
Salt and Metals as Heat Transfer Medium

Molten salts or low melting temperature metals are material groups that have immense potential as thermal energy storage and heat transfer media for solar and/or nuclear energy applications. Besides other thermophysical properties, a sufficiently low viscosity over the complete temperature range from 100 °C to 700 °C is a precondition for successful application.

Viscosity measurements on salts and metals must often be performed under dry, oxygen-free inert atmospheres. The unique vacuum and atmosphere control capabilities of the VIS 413 allow viscosity measurements on samples that are sensitive to humidity or oxygen.



Viscosity data of coal slag with and without fluxing agent added in the temperature range between 1250 °C and 1600 °C measured with VIS 413.



Viscosity of a basaltic magma as function of temperature

Geological Materials

Magma

Viscosity is the most important physical property governing the production, transport and eruption of magmas. The viscosity of naturally-occurring silicate magmas can span more than 15 orders of magnitude primarily in response to variations in temperature, melt composition and the proportions of suspended solids and/or exsolved fluid phases.

Experimental investigation of magma is the basis for improved modelling of geological processes. Cooling of mixed aluminosilicate liquids leads to partial crystallization which changes the composition of the residual liquid. This can lead to complex changes in magma viscosity which are only assessable by measurements.

In the left diagram the viscosity of a basaltic andesite magma is plotted over temperature.

TA INSTRUMENTS | COMPLEMENTARY ANALYTICAL INSTRUMENTS

High Temperature Analyzers

TA Instruments is the market leader in thermal analysis and rheology with a broad portfolio of complementary measurement technologies. Some of the instruments which are especially relevant to the high temperature viscometer VIS 413 are listed here. These can be applied for measuring thermophysical material properties in the same applications and workflows.

Discovery SDT 650 – Simultaneous Thermal Analyzer

The combined DSC/TGA instrument simultaneously provides heat flow and weight data at temperatures up to 1500 °C. It is the ideal tool to analyze phase changes like glass transition and melting as well as reactions and decomposition. With its large temperature range and controlled atmosphere capability it provides complementary material data.

DLF 1600 – Laser Flash Analyzer

The Discovery Laser Flash DLF 1600 is an advanced instrument for the measurement of thermal diffusivity and specific heat capacity of materials from room temperature to 1600 °C. With the ability to be operated in a variety of atmospheric conditions, including air, inert gas, or under vacuum, the DLF 1600 can characterize a wide variety of materials including ceramics, carbons, composites, glasses and metals.

DIL - Push Rod Dilatometers

DIL800 series dilatometers measure dimensional changes of materials as a function of temperature in the range up to 1700 °C. They can be used to test a wide range of materials including ceramics, glasses and metals. These dilatometers provide measurements of a wide variety of properties including thermal expansion, sintering, phase transitions, softening point and glass transition temperature.

HM/ODP – Heating Microscope and Optical Dilatometry Platform

Heating Microscopy and optical dilatometry are innovative and versatile techniques capable of measuring dimensional changes beyond the softening point into the melt, without contacting the sample, accurately reproducing real industrial high temperature process conditions. Characteristic temperatures the systems can automatically identify include sintering, softening, sphere, half-sphere, and melting/fusion.

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TA Instruments
159 Lukens Drive
New Castle, DE 19720 U.S.A.
T: 1 302 427 4000
F: 1 302 427 4041
www.tainstruments.com

Waters Corporation
34 Maple Street
Milford, MA 01757 U.S.A.
T: 1 508 478 2000
F: 1 508 872 1990
www.waters.com