The right temperature worldwide

Thermostats · Circulation chillers · Heating and Cooling systems
Interfacial instrumentation & Viscometry instrumentation
Company history

1956
Dr. Rudolf Wobser founds the MESSGERÄTE-WERK LAUDA Dr. R. Wobser KG in the Baden town of Lauda.

1958
Development of new types of laboratory thermostats in a modular system and development of cooling thermostats with machine cooling.

1959
The first series-production thermostats produce a considerable growth in sales.

1967
Introduction of the first Ring/Plate Tensiometer TE 1 and the Film Balance FW 1 (see picture) – the first representatives of today’s product group measuring instrumentation.

1971
Market introduction of the first automatic Capillary Viscosity Measuring System in the world.

1987
Computer controlled Tensiometer with automatic CMC determination (reverse CMC patented by LAUDA).

1989
As a result of the expanding of the range of products, the MESSGERÄTE-WERK LAUDA is renamed as LAUDA DR. R. WOBSER GMBH & CO. KG.

1991
Product introduction of first Drop Volume Tensiometer TVT 1 in the world for measuring dynamic surface and interfacial tension. At the same time, product introduction of the semi-automatic Ring/Plate Tensiometer TD 1 took place. Development of the first Bubble Pressure Tensiometer MPT 1 in the world, according to the Fainerman/Miller method (see picture).

1994
Modular processor-controlled Viscosity Measuring system PVS with modern Windows software and the automatic viscosity rinsing system VRM enter the market.

1996
LAUDA celebrates its 40th anniversary on 1st March. Further development of Bubble Pressure Tensiometer MPT 1 to MPT 2 with Windows software.

1998
Existing PVS/VRM complemented by fully automatic sampler, becomes the VAS 1. The logical step to full automation of viscosity measuring.

1999
The improved Drop Volume Tensiometer TVT 2, equipped with the latest microprocessor technology and easy to use Windows program, was presented this year.

2000
Introduction of the new generation of Ring/Plate Tensiometer TE 2 at Achema 2000.

2004
The LAUDA viscosity measuring system DVS 1 has been optimised for the parallel determination of viscosity and density. The new measuring method and uncomplicated handling enable shorter measuring times than in the case with conventional viscometers.

2005
The LAUDA viscosity measuring system PVS participates in the advantages of the LAUDA Proline thermostats. Measurements of low temperatures down to -60 °C are available.

Product advantages
- Modularity, the basic principle
- Modules at a glance
- Autosampler VAS 1
- Software

Applications
- Compatibility with laboratory environment
- Solvent viscosity of plastics
- Testing technical lubricants
- Integrated solvent recycling
- Determining enzyme activity

Technical Data & Accessories
- Modules
- Automatic cleaning
- Viscometer for offline cleaning
- Viscometer for online cleaning
- Clear-view thermostats
- Through-flow coolers
- Equipment combinations

Glossary
Modularity, the basic principle

Increasingly stringent quality specifications demand more and more accurate control of raw materials and intermediate products. Kinematic viscosity is an important characteristic of liquids with nearly Newtonian (i.e. ideal) flow behaviour. And capillary viscometry is the most accurate method for measuring it. Measurement routines should be efficient, rapid, absolutely reliable and be reproducible without limitation.

The LAUDA viscosity measuring system is built up from independent and self-contained functional units. These are linked through a central control unit to a conventional PC which controls the entire measurement sequence and evaluates the measured data. The decentralized structure enables all components to operate independently of each other. Through this independence of the modules it becomes possible to assign different measurement routines to individual places, so that routines can run independently on the different places without any mutual interaction.

Viscosity with the flow:

With LAUDA’s unique modular concept it is possible to set up system configurations which represent the optimal combination of all functionalities required for a particular application. These range from 1-place measuring systems up to 8-place systems with automatic cleaning and the 4-place system with auto-sampler. A very high degree of automation is achieved for repeated measurement routines. The numerous operations which are often still performed manually today are thus reduced to a minimum.

Using these individual configurations, viscosities and characteristics derived from them can be evaluated for a great variety of materials:

- **Plastics**: measuring relative, reduced and intrinsic viscosity as a measure of mean molecular weight and thus of polymer length which defines quality.

- **Lubricants, oil and fuel**: measuring viscosity and its variation with temperature as well as viscosity indexes of mineral oil products, additives and their mixtures according to ASTM and ISO standards.

- **Enzyme activity**: determining the reaction activity of certain enzymes from their effect on the time change in the flow characteristic of dissolved biological molecules.

- **Cellulose**: determining the chain length of basic materials for technical papers and textiles, and the change in polymer length over various processing stages and due to wear.

Module adjustment to application

The modular structure offers application-related solutions with extensive extension options with regard to the degree of automation and ease of evaluation. The affordable single-place measuring system in its minimally-configured form already contains the basic components. This can be further extended through to the four-place fully-automated systems with sample charging and automatic cleaning and integrated solvent recycling and inclusion of the sample preparation. The pressing objective of this is to make the measurements and their preparation independent of the relevant user, and to simultaneously free the user from routine activities, e.g. dealing with hazardous solvents.
Autosampler VAS 1

The VAS 1 autosampler is the ideal modular complement when large sample throughputs and regularly repeated measurement routines are involved. Monotonous and time-consuming operations are automated, the operators can concentrate on more important tasks. The effort required per measurement, from filling the viscometer up to its final cleaning, is greatly reduced, permitting efficient loading of the measuring system. Typically up to 160 samples can be evaluated in 10 hours, and correspondingly more with shift operation. The operator no longer comes into contact with irritating, corrosive, poisonous or hot substances.

The modular structure also permits economic system arrangements which are optimally matched to actual requirements. The configuration can thus be adapted to a larger sample throughput, to new tasks, or to the integration of newly developed modules.

**Better reproducibility and precision**

The autosampler fills up to four viscometers in parallel with the same or different samples. A syringe draws up the sample through the viscometer capillary is measured to the nearest millisecond, using a novel infrared sensor controlled by a single-chip processor. The sturdy micro pump for transferring the sample up to the bulb, together with the chemical-resistant valves in the stand head, ensure very compact construction and reliable long-term operation.

**Control unit PVS 1**

is the central module of the system and at the same time forms the link between the PC and individual components. The control unit provides a total of four slots which, depending on configuration, can be fitted with modules for one (ME 1) or two (ME 2) measuring stands, dosing systems (BE), or the autosampler (VAS/E) and magnetic stirrer control (MRE).

**Measuring stand S 5**

can carry different standard capillary viscometers, for example the types Ubbelohde (see illustration) or Cannon-Fenske Routine. The time for the sample to flow through the viscometer capillary is measured to the nearest millisecond, using a novel infrared sensor controlled by a single-chip processor. The sturdy micro pump for transferring the sample up to the bulb, together with the chemical-resistant valves in the stand head, ensure very compact construction and reliable long-term operation.

**Autosampler VAS 1**

complements a 4-place measuring system to provide maximum automation convenience with an extremely high sample throughput. Up to 63 samples, depending on reservoir size, can be processed in one setting. Also hot polymer solutions or oils can be handled in heated rack with heated dosing syringe.

**Cleaning module VRM**

provides fully automatic cleaning and drying of the viscometers. Either one (VRM 1) or two (VRM 2) viscometers can be connected and two different cleaning liquids can be selected separately. Even very hot samples up to 180 °C can be handled reliably (VRM 22/HT). Use of high-grade materials ensures absolute chemical resistance.

**Dosing system**

for determining limiting viscosity through different concentration steps, in conjunction with a dilution viscometer, a magnetic stirrer operating from the burette module (BE) it can be controlled via measuring software.

**Thermostat**

Precise measurement of viscosity demands that the test temperature is kept constant and uniform throughout the bath. LAUDA clear-view thermostats, or LAUDA Ecoline StarEdition thermostats in conjunction with a transparent bath are important elements permitting unrestricted observation of the capillary viscometers.

**Efficiency**

- Automation of time-consuming, labour-intensive manual operations
- Very large sample throughput
- Daily capacity can be accurately predicted

**Functionality**

- Automatic filling of up to four independently operating viscometers
- Automatic emptying and cleaning with up to two cleaning liquids
- Facility for mixed operation with two sample types dissolved in different media
- Operations controlled completely by PC
- Maximum safety in handling dangerous substances

**Number of samples handled by one operator in 10 hours**

- 5 samples per hour
- 160 samples in 10 hours

**Time actually used by operator**

- 10 minutes
- 100 minutes
- 90 minutes
- 10 minutes

**Sequence of individual tests and sample assignment are determined by the PC or can be conveniently set by the user.**
Good laboratory practice requires extensive independence of the measuring conditions by the operating staff. This means that as far as possible no critical measurement parameters such as for example sample descriptions and concentrations can be entered unmonitored. If inputs are required, these must be correspondingly authorised. The software in the PVS is capable of reading in finished lists with all parameters provided by the LIMS; this also applies to concentration entries that can be read in directly from the communication-capable balances and dosing systems. The sample number can be transmitted to the display of the balance at the same time. This is effected from the measuring computer independently via a separate software module.

**Compatibility with the laboratory environment**

All PVS system configurations are operated via an interface by a conventional PC. The powerful and user-friendly PC program in its standard version also performs all necessary calculations for determining kinematic, dynamic, relative, reduced and inherent viscosity as well as the K-value, completely automatically on the basis of the measurements. Further substance characteristics can be obtained with additional software modules which can be interconnected to the basic software.

### Software

#### Software on Windows basis

- **Basic software**
  - Windows software, running on all conventional PCs and operating systems
  - Parallel operation on up to eight places
  - Calculation and presentation of - flow times and their average - standard deviation - kinetic energy correction e.g. Hagenbach correction or ISO 16284 - absolute kinematic viscosity - absolute dynamic viscosity - relative viscosity - reduced viscosity (viscosity number) - inherent viscosity (logarithmic viscosity number) - K-value after Fickentscher

- **Additional software modules**
  - INV-DLL determines the intrinsic viscosity of polymers (limiting viscosity, Staudinger index) and their average molecular weight (chain length)
  - VID-DLL evaluates the viscosity index of oil according to ISO 2369, ASTM 2273, ASTM 445/446 and IP 226/91
  - ENZ-DLL determines the reaction activity of certain enzymes by variation of viscosity with time
  - TEMP-DLL enables the setting and control of temperature of thermostats e.g. to record viscosity versus temperature dependence (e.g. 215 T, PV (L) 15°, PV (L) 24° and PV 36°)

Additional software modules obtain further substance characteristics.

**Access authorisations and documentation simplify the measurements**

All users must log in with their own account and password and have limited access to the system dependent on a level of authorisation they enjoy. This means that shift staff can only read in finished lists and can activate a series of measurements without need for making any entries themselves. The automatic documentation records all results and users chronologically in daily protocol files and log files order as well as alterations made to parameters as required for example in FDA Standard 21CFR Part 11.

**Features**

- Extensive support from GLP and 21 CFR part 11
- Automatic integration of the sample preparation
- Supports conventional balances and dosing systems
- User-specific connection to LIMS available

**Example equipment**

- Autosampler VAS 1/4 (complete)
- Analytic balance AX series
- Buretta 765
- LIMS software module (as per user specification)
- Stirrer block MRH 15

**Additional software modules**

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*is adapted with RS 232 interface LRZ 913

**Communication channels**

**Database**

- Test number
- Task concentration
- Weight

**Dosing system**

- Task list
- Balance protocols
- Task results

**Balance**

- Task
- Concentration

**LIMS**

- Communication channels

**Example software modules**

- INV-DLL evaluates the viscosity index of oil according to ISO 2369, ASTM 2273, ASTM 445/446 and IP 226/91
Almost all standardised methods based on solvent viscometry for the analysis of polymers can be realised in accordance with the specific application by means of the PVS. The most important standards for general solvent viscosity are ISO 1628/1, DIN 53728/1, ASTM D 2857; for PVC (polyvinyl chloride) are ISO 1628/2, DIN 53726, ASTM D 1243; for PE/PP (polyolefines) are ISO 1628/3, DIN 53728/4, ASTM D 1691; for PC (polycarbonates) are ISO 1628/4, DIN 7744; for PET/PBT (polyester) are ISO 1628/5, DIN 53728/2, ASTM D 4603; for PMMA (polymethyl metacrylates) are ISO 1628/6, and for PA (polyamides) are ISO 307, DIN 53727, ASTM D 789.

Solvent viscosity of plastics

Plastics industry today demands a large number of quality controls. From the raw material, through intermediate products and up to final processing, the average chain length of polymers with its decisive importance for quality, and its changes with mechanical and thermal processing have to be checked again and again. The determination of solvent viscosity is here one of the most widely proven and sensitive methods.

Optimum system solutions for standard and special applications

The standard version of the PVS software already calculates automatically the relative and reduced viscosities, inherent viscosity and the K-value after Fickentscher. With the software module INV-DLL it is possible to determine the intrinsic viscosity by approximation formulae, either from one sample concentration (single-point method) or from different sample concentrations by extrapolation through linear regression. Intrinsic viscosity leads to mean molecular mass and from there to the chain length of a polymer. There are also tailor-made arrangements for polyolefines, such as polyethylene and polypropylene which can only be dissolved and tested at very high temperatures.

Use of viscometry in motorcar production as an example

Manufacture of intermediate products:
- quality control of the granulates supplied
- quality control of intermediate products

Motorcar manufacture:
- research and development of plastic components
- quality control of finished plastic components

Preparation of polymer granulates:
- research and development
- production control
- quality control

Testing technical lubricants

Parallel linear regression

This is the fastest method on the market for performing linear regression. One measurement including cleaning takes only 25 minutes. The different sample concentrations required are evaluated virtually simultaneously on three to six places using independently operating measuring stands.

Serial linear regression

This method can be performed using only one place. Between the individual measurements the sample is successively diluted in the viscometer itself, using an automatic burette. A magnetic stirrer ensures rapid thermostating and uniformity of the sample after each concentration change. Apart from simplified operation, the main feature is highly precise dosing resulting in concentration series with excellent reproducibility.

Single-point methods

Although these are based on approximate formulae with limited application and accuracy, they can be performed very rapidly on any PVS configuration since measurement at a single concentration only is required. The following methods are offered:

- Point/slope method
- Schulz-Blaschke method
- Huggins method
- Solomon-Ciuta method
- Billmeyer method

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Typical specification

- Control unit PVS 1/1
- 4 Measuring stands S 5
- 4 Ubbelohde dilution viscometers
- PC with software module INV-DLL
- Thermostat E 215 T with cover plate MD 15 V/K
- Through-flow cooler DLK 10 or cooling water connection

Minimum specification

- Control unit PVS 1/1
- 3 Measuring stands S 5
- 3 KPG Ubbelohde viscometers
- PC with software modul INV-DLL
- Thermostat PV 24 with cover plate D 20 V
- Through-flow cooler DLK 10 or cooling water connection

Measuring system for polyolefines

This configuration permits simple and reliable measurement of the viscosity of polyethylene and polypropylene sulfide solutions at temperatures up to 180 °C. The sample, granulate or powder is placed directly into the dilution viscometer with integrated filters and is dissolved there, with the solvent required for this and for the subsequent dilution steps added precisely from a burette. Manual handling of hot samples or solvents, as usually required, has become unnecessary.

Minimum specification

- Control unit PVS 1/1
- Measuring stand S 5
- KPG Ubbelohde viscometer
- PC with software modul INV-DLL
- Thermostat E 215 T with cover plate MD 15 V/K
- Through-flow cooler DLK 10 or cooling water connection

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The precision of the absolute kinematic viscosity measured using the LAUDA PVS system considerably exceeds the requirements determined in the standards. The LAUDA PVS in its optimised configured form is thus an ideal choice for the determination of viscosimetric characteristics such as of mineral oils, other oils and their derivatives. The LAUDA PVS-System complies with many international standards, like kinematic viscometry DIN 51562/1-3, ASTM D 445-446, IP 71 and ISO 3104-3105 and for determination of the viscosity index ASTM D 2270 and ISO 2909.

In many cases only rinsing agents that are capable of completely dissolving polymers and oils can be used for the necessary thorough cleaning of viscometers. The rinsing solvents suitable for such a task are frequently chlorinated or toxic. Highly volatile rinsing solvents such as dichloromethane and chloroform, as well as acetone, THF and some others can only be recovered automatically online by recooling, and this in the circuit directly out of waste bottle and back into the rinsing supply bottle.

Wide temperature ranges

<table>
<thead>
<tr>
<th>Boiling point (°C)</th>
<th>Dichlormethane</th>
<th>Acetone</th>
<th>Chloroform</th>
<th>Ethylalcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.0</td>
<td>56.5</td>
<td>61.0</td>
<td>78.5</td>
<td></td>
</tr>
<tr>
<td>-10.0</td>
<td>-10.0</td>
<td>-10.0</td>
<td>-10.0</td>
<td></td>
</tr>
<tr>
<td>51.6</td>
<td>73.9</td>
<td>82.0</td>
<td>95.5</td>
<td></td>
</tr>
<tr>
<td>350.0</td>
<td>350.0</td>
<td>230.0</td>
<td>200.0</td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>3.3</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>5.0</td>
<td>6.0</td>
<td>5.0</td>
<td></td>
</tr>
</tbody>
</table>

Low-temperature viscosity

With the PVS system it is possible to determine the viscosity of fuel, e.g. for aircraft, under actual conditions of use to -60 °C. For the first time this is now also possible including automatic cleaning down to -20 °C. In addition to high-power LAUDA refrigeration units and specially insulated clear-view thermostats the method involves a cold trap for air drying. With software module TEMP-DLL the temperature of thermostats can be controlled and changed e.g. to determine the viscosity versus temperature dependency.

Easy solvent handling

For this PVS system with rinsing modules VRM 22 is required in which the sample and the rinsing agent are aspirated by means of a vacuum membrane pump into a waste bottle. If this pump is fitted with a heat exchanger, the times between the rinsing processes can be utilised for recondensation of the solvent as the pump continues to run, reducing the pressure in the waste bottle down to the boiling pressure.

Evaporated solvent passes at the recooler where it is condensed and returned as purified liquid directly into the rinsing supply bottle. As the pump is used twice to aspirate the viscometer empty and to evaporate the rinsing agent, merely an additional recooler, and thermostating devices are required to cool the condensers and to keep the waste solvent boiling.

Apart from the money savings, handling of the solvent is also reduced as the necessity to refill is greatly lowered or is not even necessary, in case the sample solvent is the same as the rinsing solvent. Only LAUDA offers such an integrated solution that can be used for different equipment levels.
Determining enzyme activity

Solutions of certain biological macromolecules alter their viscosity under the influence of enzymes as these effectively cut the dissolved molecular chains. Such situations permit very accurate evaluation of enzyme activity by measuring the variation of relative viscosity during the course of the enzyme reaction.

Automatic control of the measuring sequence

Apart from controlling the measurement sequence, the software module ENZ-DLL automatically calculates and outputs enzyme activity for hyaluronidase and cellulase from a comparison with reference measurements, in accordance with international pharmaceutical standards.

Regression line of relative viscosity against reaction time

In addition the logarithmic relative viscosity against reaction time is presented graphically by the software module ENZ-DLL drawing the regression line through the test points and determine the reacting half-life.

Modules

PVS control units PVS 1

<table>
<thead>
<tr>
<th>PVS 1/1…1/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. number of places</td>
</tr>
<tr>
<td>PC interface</td>
</tr>
<tr>
<td>Dimensions (WxDxH) mm</td>
</tr>
<tr>
<td>Weight (net) kg</td>
</tr>
<tr>
<td>Ambient temperature °C</td>
</tr>
<tr>
<td>Total loading kW</td>
</tr>
<tr>
<td>Supply V; Hz</td>
</tr>
</tbody>
</table>

Measuring stands S 5

- Meniscus detection optical (infrared)
- Light detector control digital (µP)
- Sample temperature range °C | 65...180*
- Timing range s | 0…9999,99
- Recommended flow timing range s | 30...1000
- Viscosity range mm²/s | 0.3...5000
- Timing resolution s | 0.01
- Timing accuracy ppm | 1
- Dimensions (WxDxH) mm | 90x90x500
- Weight (net) kg | 4.5

Rinsing modules VRM 2

<table>
<thead>
<tr>
<th>VRM 22/HT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample temperature range °C</td>
</tr>
<tr>
<td>Viscosity range mm²/s</td>
</tr>
<tr>
<td>Max. number of solvents</td>
</tr>
<tr>
<td>Dimensions (WxDxH) mm</td>
</tr>
<tr>
<td>Weight (net) kg</td>
</tr>
</tbody>
</table>

Autosampler VAS 1

<table>
<thead>
<tr>
<th>VRM 22/HT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample temperature range °C</td>
</tr>
<tr>
<td>Viscosity range mm²/s</td>
</tr>
<tr>
<td>Syringe volume °C</td>
</tr>
<tr>
<td>Max. number of samples (50 ml)</td>
</tr>
<tr>
<td>Max. number of samples (25 ml)</td>
</tr>
<tr>
<td>Max. number of places</td>
</tr>
<tr>
<td>Dimensions (WxDxH) mm</td>
</tr>
<tr>
<td>Weight (net) kg</td>
</tr>
</tbody>
</table>

*higher temperatures to special order
**can be extended using samples predilution and connection set 8

Features

- Up to 99 individual measurements, cover of changes over a wide range of time
- Depending of system up to 8 measurements in parallel
- Reaction start (determined by mixing of solution) can be transferred by key stroke
- Setting of delay time and automatically start of measurements
**Accessories**

**Control unit PVS 1**

- **Type**
  - PVS 1/1 incl. 1 x ME 1 (for 1 place)
  - PVS 1/2 incl. 1 x ME 2 (for 2 places)
  - PVS 1/3 incl. 2 x ME 2 (for 3 places)
- **Cat. No.**
  - LMV 915
  - LMV 916
  - LMV 918

**Plug-in extension cards**

- 2-place measurement card (ME 2) (for up to 2 places)
- Burette module (BE) for up to 2 burettes (65)
- Magnetic stirrer control module (for max. 4 stirrers)
- Port control module (VAD/S)
- (in connection to the VAS autosampler)

**Autosampler VAS 1 and accessories**

- **Cat. No.**
  - LMV 818
  - LMV 819

**Software and accessories for sample preparation**

- **Type**
  - Analytic balance AX 204
  - Burette 765 (fully automatic)
  - Sering block MRH 15 (for 100 ml flasks)
  - Adapter rings for 50 ml flasks
  - Connecting cable for Burette 765
  - Software with own data base
- **Cat. No.**
  - EBK 006
  - EBK 003
  - EBK 009
  - EQ 062
  - UK 253
  - LDVM 4022

**Syringe Wash station 1 for VAS 1**

- **Cat. No.**
  - LMVZ 941

**Syringe Wash station 2 for VAS 1**

- **Cat. No.**
  - LMVZ 951

**Connecting set 4 for viscometers with aspiration tube**

- **Cat. No.**
  - LMRZ 914

**Connecting set 5 for viscometers without aspiration tube**

- **Cat. No.**
  - LMRZ 921

**Sample rack PD 50, not heated**

- **Cat. No.**
  - LMVZ 939
  - LMVZ 947

**Mounting set for stirrer block MRH 15**

- **Cat. No.**
  - LMVZ 963

**Mounting set for stirrer block MRH 24** (heated, max. 160°C)

- **Cat. No.**
  - LMVZ 946

**Flasks (50 ml), with GL32 thread for PG 50**

- **Cat. No.**
  - EQ 062

**Filter element for EG 062 (1 for each EG 062)**

- **Cat. No.**
  - LMVZ 958

**Coupling cap (1 x for each EG 062 necessary)**

- **Cat. No.**
  - EZV 100

**Sealing rings (50 pieces) for EZV 100**

- **Cat. No.**
  - EDF 122

**Aluminium-plates (5 x 1000 pieces) for EG 062**

- **Cat. No.**
  - EDF 207

**Flasks (30 ml), with GL32 thread for PG 30**

- **Cat. No.**
  - EQ 066

**Autosampler VAS 1 and accessories**

- **Cat. No.**
  - EZV 104
  - EDF 124
  - EDF 092
  - EBE 038
  - UD 442
  - UD 516
  - EBE 037
  - LMVZ 157

**Software modules**

- **Type**
  - Software module IM-DLL (intrinsic viscosity)
  - Software module VD-DLL (viscosity index to ISO 2909)
  - Software module ENZ-DLL (enzyme activity)
  - Software module TEMP-DLL (temperature control and dependence)
- **Cat. No.**
  - LDVM 4015
  - LDVM 4016
  - LDVM 4017
  - LDVM 4023

**Dosing system**

- **Type**
  - Burette 765
  - Burette set 1 for operation without VRM 2
  - Burette set 2 for operation with VRM 2
- **Cat. No.**
  - EBK 003
  - LMVZ 931
  - LMVZ 932

**Additional accessories**

- **Type**
  - Draining rack (for filling and drying)
  - Bottle
  - Connecting cap, small, silicone
  - Connecting cap, large, silicone
  - Connecting cap, small, viton
  - Connecting cap, large, viton
  - Connecting cap, large, silicone (for dilution series)
  - Silicon tubes, 3 x 1.5 mm
  - Viton tube, 3 x 1.5 mm (for sulfic acid)
  - Connecting cable burette <-> PVS
  - FTFE stirrer
- **Cat. No.**
  - UU 004
  - LMV 934
  - HKA 901
  - HKA 002
  - HKA 147
  - HKA 148
  - HKA 119
  - RKJ 014
  - RCI 020
  - UK 237

**Software and accessories for automatic cleaning**

- **Cat. No.**
  - EZV 104
  - EDF 124
  - EDF 092
  - EBE 038
  - UD 442
  - UD 516

**Software modules**

- **Type**
  - Software module IM-DLL (intrinsic viscosity)
  - Software module VD-DLL (viscosity index to ISO 2909)
  - Software module ENZ-DLL (enzyme activity)
  - Software module TEMP-DLL (temperature control and dependence)
- **Cat. No.**
  - LDVM 4015
  - LDVM 4016
  - LDVM 4017
  - LDVM 4023

**Dosing system**

- **Type**
  - Burette 765
  - Burette set 1 for operation without VRM 2
  - Burette set 2 for operation with VRM 2
- **Cat. No.**
  - EBK 003
  - LMVZ 931
  - LMVZ 932

**Additional accessories**

- **Type**
  - Draining rack (for filling and drying)
  - Bottle
  - Connecting cap, small, silicone
  - Connecting cap, large, silicone
  - Connecting cap, small, viton
  - Connecting cap, large, viton
  - Connecting cap, large, silicone (for dilution series)
  - Silicon tubes, 3 x 1.5 mm
  - Viton tube, 3 x 1.5 mm (for sulfic acid)
  - Connecting cable burette <-> PVS
  - FTFE stirrer
- **Cat. No.**
  - UU 004
  - LMV 934
  - HKA 901
  - HKA 002
  - HKA 147
  - HKA 148
  - HKA 119
  - RKJ 014
  - RCI 020
  - UK 237
Viscometers for offline cleaning

Ubbelohde viscometers
ISO 3105, DIN 51562, BS 188, NFT 60–100.
Filling volume: 15...20 ml
Total length: 290 mm approx.
Accuracy: ± 0.1%, calibrated for absolute measurement, for automatic measurement.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.001</td>
<td>EGV 690</td>
</tr>
<tr>
<td>0a</td>
<td>0.003</td>
<td>EGV 700</td>
</tr>
<tr>
<td>0c</td>
<td>0.005</td>
<td>EGV 701</td>
</tr>
<tr>
<td>I</td>
<td>0.01</td>
<td>EGV 702</td>
</tr>
<tr>
<td>Ia</td>
<td>0.03</td>
<td>EGV 703</td>
</tr>
<tr>
<td>Ic</td>
<td>0.05</td>
<td>EGV 691</td>
</tr>
<tr>
<td>II</td>
<td>0.1</td>
<td>EGV 704</td>
</tr>
<tr>
<td>IIa</td>
<td>0.3</td>
<td>EGV 705</td>
</tr>
<tr>
<td>IIc</td>
<td>0.5</td>
<td>EGV 692</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>EGV 706</td>
</tr>
<tr>
<td>IIIa</td>
<td>3</td>
<td>EGV 707</td>
</tr>
<tr>
<td>IIIc</td>
<td>5</td>
<td>EGV 693</td>
</tr>
<tr>
<td>IV</td>
<td>10</td>
<td>EGV 708</td>
</tr>
<tr>
<td>IVa</td>
<td>30</td>
<td>EGV 699</td>
</tr>
<tr>
<td>IVc</td>
<td>50</td>
<td>EGV 698</td>
</tr>
</tbody>
</table>

Micro-Ubbelohde viscometers
Filling volume: 2...3 ml
Total length: 290 mm approx.
Accuracy: ± 0.5%, calibrated for automatic measurement.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.01</td>
<td>EGV 718</td>
</tr>
<tr>
<td>Ia</td>
<td>0.03</td>
<td>EGV 719</td>
</tr>
<tr>
<td>II</td>
<td>0.1</td>
<td>EGV 720</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>EGV 721</td>
</tr>
</tbody>
</table>

Cannon-Fenske-Routine viscometers
ISO 3105, ASTM D 2515, BS 188
Filling volume: 5...10 ml
Total length: 245 mm approx.
Accuracy: ± 0.2%, calibrated for automatic measurement.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.002</td>
<td>EGV 820</td>
</tr>
<tr>
<td>Ia</td>
<td>0.008</td>
<td>EGV 821</td>
</tr>
<tr>
<td>II</td>
<td>0.04</td>
<td>EGV 822</td>
</tr>
<tr>
<td>IIa</td>
<td>0.15</td>
<td>EGV 823</td>
</tr>
<tr>
<td>III</td>
<td>0.035</td>
<td>EGV 824</td>
</tr>
</tbody>
</table>

Micro-Ostwald viscometers
Recommended with pronounced foaming and/or small liquid quantities
Filling volume: 2 ml
Total length: 290 mm approx.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.01</td>
<td>EGV 820</td>
</tr>
<tr>
<td>Ia</td>
<td>0.03</td>
<td>EGV 821</td>
</tr>
<tr>
<td>II</td>
<td>0.1</td>
<td>EGV 822</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>EGV 823</td>
</tr>
</tbody>
</table>

Dilution-Ubbelohde viscometers
For determining the intrinsic viscosity
Filling volume: 15...75 ml
Total length: 290 mm approx.
Accuracy: ± 0.1%, uncalibrated, for automatic measurement.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0011</td>
<td>EGV 920</td>
</tr>
<tr>
<td>0a</td>
<td>0.005</td>
<td>EGV 921</td>
</tr>
<tr>
<td>0c</td>
<td>0.001</td>
<td>EGV 922</td>
</tr>
<tr>
<td>I</td>
<td>0.01</td>
<td>EGV 923</td>
</tr>
<tr>
<td>II</td>
<td>0.1</td>
<td>EGV 924</td>
</tr>
</tbody>
</table>
*also available with integrated filter

Viscometer holders and accessories:

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapter MUO, required for use of Micro-Ubbelohde or Micro-Ostwald viscometers</td>
<td>HKB 532</td>
</tr>
<tr>
<td>Ubbelohde viscometer holder*</td>
<td>UG 003</td>
</tr>
<tr>
<td>Cannon-Fenske viscometer holder*</td>
<td>UG 084</td>
</tr>
<tr>
<td>Micro-Ostwald viscometer holder*</td>
<td>UG 094</td>
</tr>
</tbody>
</table>

Calculation formula:
Kinematic viscosity = (K x flow time) / Hagenbach correction

Viscometers for online cleaning

Ubbelohde viscometers
ISO 3105, DIN 51562, BS 188, NFT 60–100
With filling and cleaning tube
Filling volume: 5...10 ml
Total length: 245 mm approx.
Accuracy: ± 0.2%, calibrated for automatic measurement.
Only in conjunction with VRM modules.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.002</td>
<td>EGV 950</td>
</tr>
<tr>
<td>75</td>
<td>0.008</td>
<td>EGV 951</td>
</tr>
<tr>
<td>50</td>
<td>0.004</td>
<td>EGV 952</td>
</tr>
<tr>
<td>100</td>
<td>0.015</td>
<td>EGV 953</td>
</tr>
<tr>
<td>150</td>
<td>0.035</td>
<td>EGV 954</td>
</tr>
<tr>
<td>250</td>
<td>0.1</td>
<td>EGV 955</td>
</tr>
<tr>
<td>350</td>
<td>0.5</td>
<td>EGV 956</td>
</tr>
<tr>
<td>500</td>
<td>0.25</td>
<td>EGV 957</td>
</tr>
<tr>
<td>600</td>
<td>1.2</td>
<td>EGV 958</td>
</tr>
</tbody>
</table>

Cannon-Fenske-Routine viscometers
ISO 3105, DIN 51562, BS 188
With filling and cleaning tube
Filling volume: 5...10 ml
Total length: 245 mm approx.
Accuracy: ± 0.2%, calibrated for automatic measurement.

<table>
<thead>
<tr>
<th>Type</th>
<th>K</th>
<th>Cat. No.</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
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<td>EGV 952</td>
</tr>
<tr>
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<td>0.015</td>
<td>EGV 953</td>
</tr>
<tr>
<td>150</td>
<td>0.035</td>
<td>EGV 954</td>
</tr>
<tr>
<td>250</td>
<td>0.1</td>
<td>EGV 955</td>
</tr>
<tr>
<td>350</td>
<td>0.5</td>
<td>EGV 956</td>
</tr>
<tr>
<td>500</td>
<td>0.25</td>
<td>EGV 957</td>
</tr>
<tr>
<td>600</td>
<td>1.2</td>
<td>EGV 958</td>
</tr>
</tbody>
</table>

Adapters

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapter MUO, required for use of Micro-Ubbelohde or Micro-Ostwald viscometers</td>
<td>HKB 532</td>
</tr>
<tr>
<td>Ubbelohde viscometer holder*</td>
<td>UG 003</td>
</tr>
<tr>
<td>Cannon-Fenske viscometer holder*</td>
<td>UG 084</td>
</tr>
<tr>
<td>Micro-Ostwald viscometer holder*</td>
<td>UG 094</td>
</tr>
</tbody>
</table>

*holder fits only LAUDA viscometers
LAUDA clear-view thermostats are available in various bath sizes and for various bath depths, as both a Master and a Command version. All clear-view thermostats are equipped with a Varioflex pump. The larger cooling coils, which come built in as standard, offer a more effective cooling capacity, especially for large baths. An easily-accessible drain tap on the side of the thermostat plus handle simplify mobility.

LAUDA Proline clear-view thermostats ensure accurate and reliable thermostating of objects placed in the bath. Because of the transparent front panel or the transparent bath vessel they are particularly suitable for viscometry. Provision of a special cover plate makes the thermostats suitable for use with capillary viscometers and the stands of the PVS viscosity measuring system. In addition the models series PV and PVL incorporate an unique 2-chamber system: separation into a measurement and a thermostating chamber offers decisive advantages in the measurement chamber: constant liquid level, very small temperature gradient, maximum temperature stability. In addition they incorporate a powerful pump and connectors for connecting to LAUDA through-flow coolers. The Ecoline Staredition thermostats E 115 T and E 215 T offer a lower-priced alternative in the temperature range up to 100 °C.

Through-flow coolers not only render mains water cooling unnecessary, they also prevent undesirable fluctuations in the flow rate and ensure constant cooling water temperature. This leads to optimum temperature control over the entire measurement period which in turn has a very positive effect on the accuracy and reproducibility of the measurements.

**Clear-view thermostats**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Thermostat</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 °C</td>
<td>E 115 T</td>
<td>E 215 T PV 15 PV 24 PV 36 PVL 15 PVL 24</td>
</tr>
<tr>
<td>150 °C</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Operating temp. range °C**

| 20...100    | 20...100   | 30...230   | 30...230   | 30...230   | 30...100   |

**Temperature stability °C**

| 0.02       | 0.02       | 0.02       | 0.02       | 0.02       |

**Resolution of setting °C**

| 0.01/0.01 | 0.01/0.01 | 0.01/0.01 | 0.01/0.01 |

**Safety fittings**

| III, FL    | III, FL    | III, FL    |

**Heater power kW**

| 1.5       | 2.25       | 3.5       |

**Heat exchanger connection**

| M 16 x 1.13 mm dia. nipple |

**Pump flow max. (pressure) l/min**

| 17 | 17 | 25 | 25 | 25 | 25 |

**Bath depth mm**

| 310 | 320 | 320 | 320 | 320 | 320 |

**Usable depth mm**


**Cooling output at, gross kW**

-15 °C | 20 °C |

| 0.25 | 0.33 |

| 0.33 | 1.10 |

**Operating temp. range °C**

-20 °C | -10 °C |

| 0.10 | 0.22 |

| 0.25 | 0.75 |

**Heat exchanger connection**

| 1-2 |

**Through-flow coolers**

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-place set</td>
<td>E 115 T, E 215 T</td>
</tr>
<tr>
<td>2-place fitting set</td>
<td>PV 15</td>
</tr>
<tr>
<td>4-place fitting set</td>
<td>PV 24</td>
</tr>
</tbody>
</table>

**Magnetic stirrer sets for determining the intrinsic viscosity by serial regression**

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-place set</td>
<td>E 115 T, E 215 T</td>
</tr>
<tr>
<td>2-place fitting set</td>
<td>PV 15</td>
</tr>
<tr>
<td>4-place fitting set</td>
<td>PV 24</td>
</tr>
</tbody>
</table>

**Essential accessories:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting cable</td>
<td>UK 263</td>
</tr>
</tbody>
</table>

**Recommended accessories:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump link</td>
<td>LMRZ 044</td>
</tr>
</tbody>
</table>

*Not suitable when using Silicone oil.*
The table below shows the system combinations for thermostating the viscometers:

<table>
<thead>
<tr>
<th>Comb. No.</th>
<th>Tmax (°C)</th>
<th>Tmin (°C)</th>
<th>Max. No. places Type</th>
<th>Cat. No.</th>
<th>Type</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>30</td>
<td>2</td>
<td>E 115 T</td>
<td>LCD 263</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>20</td>
<td>2</td>
<td>E 215 T</td>
<td>LCD 264</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>5</td>
<td>2</td>
<td>E 115 T</td>
<td>LCD 263</td>
<td>Tap water</td>
</tr>
<tr>
<td>4</td>
<td>230</td>
<td>30</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 276</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>230</td>
<td>25</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 276</td>
<td>DLK 10</td>
</tr>
<tr>
<td>6</td>
<td>230</td>
<td>10</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 276</td>
<td>DLK 10</td>
</tr>
<tr>
<td>7</td>
<td>230</td>
<td>30</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 276</td>
<td>Tap water</td>
</tr>
<tr>
<td>8</td>
<td>230</td>
<td>25</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 276</td>
<td>Tap water</td>
</tr>
<tr>
<td>9</td>
<td>230</td>
<td>15</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 276</td>
<td>DLK 10</td>
</tr>
<tr>
<td>10</td>
<td>230</td>
<td>30</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 276</td>
<td>Tap water</td>
</tr>
<tr>
<td>11</td>
<td>230</td>
<td>25</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 276</td>
<td>Tap water</td>
</tr>
<tr>
<td>12</td>
<td>230</td>
<td>15</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 276</td>
<td>DLK 10</td>
</tr>
<tr>
<td>13</td>
<td>100</td>
<td>-20</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 282</td>
<td>DLK 45</td>
</tr>
<tr>
<td>14</td>
<td>100</td>
<td>-20</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 284</td>
<td>DLK 45</td>
</tr>
<tr>
<td>15</td>
<td>100</td>
<td>-40</td>
<td>2</td>
<td>PV 15</td>
<td>LCD 282</td>
<td>DLK 45 Lab</td>
</tr>
<tr>
<td>16</td>
<td>100</td>
<td>-40</td>
<td>2</td>
<td>PV 24</td>
<td>LCD 284</td>
<td>DLK 45 Lab</td>
</tr>
</tbody>
</table>

Cooling

- **Clear-view thermostats/external baths**
  - **Comb. No.**
  - **Tmax (°C)**
  - **Tmin (°C)**
  - **Max. No. places**
  - **Type**
  - **Cat. No.**

- **Cooling**
  - **Cat. No.**

Background illumination and accessories

<table>
<thead>
<tr>
<th>Type</th>
<th>Cat.-Nr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL Abbehalmamp 10 (for PV 15 and PV 15)</td>
<td>LTZ 091</td>
</tr>
<tr>
<td>AL Abbehalmamp 20 (for PV 24 and PV 24)</td>
<td>LTZ 092</td>
</tr>
<tr>
<td>AL Abbehalmamp 30 (for PV 34)</td>
<td>LTZ 093</td>
</tr>
<tr>
<td>Filter for thermostating bath</td>
<td>EG 045</td>
</tr>
<tr>
<td>Flow indicator (necessary when using EG 065)</td>
<td>EZ 204</td>
</tr>
<tr>
<td>Viscometer holder for 2-legged capillaries (for manual measurement only)</td>
<td>EZ 054</td>
</tr>
</tbody>
</table>

21 CFR-11

The guideline 21 CFR, part 11, issued by the American FDA authority, regulates the technical and organisational requirements which must be fulfilled in order to use electronic data and documents instead of paper in the development, authorisation and production processes.

Billmeyer formula (IV value according to Billmeyer)

Serves the purpose of the approximate calculation of the intrinsic viscosity of polyesters and others. No additional polymer characteristic data required.

\[ \nu_i = \frac{\nu_{rel} - 1}{K \cdot \nu \cdot \ln C} \]

**Dynamic viscosity**

Is essential to the shear flows, viscosity coefficient, between shearing strength \( \tau \) and speed gradient \( D \). For \( \tau \approx \eta \), and for \( \eta \) D, and has the unit \( \text{Pa s} \) (formerly: centipoise, cps).

FDA

Abbreviation for the Food and Drug Administration, United States. Prescribes binding guidelines for the development and production of phar-maceutical products: it is internationally valid.

Glass viscometer

Viscometers made from glass, bearing different various designs, stand-dardised in ISO 3156. The most common for automatic measurements is the Ubbelohde version with ventilation pipe.

GLP

Abbreviation for “Good Laboratory Practice”. Specification standards initiated by the FDA American authority for laboratories and producers (e.g. of pharmaceuticals) regarding how tests and measurements are to be clearly planned, performed and monitored. The guidelines have a legal character in many countries.

Hagen Poiseuille’s Law

(Fundamental equation of the capillary viscometry) This forms the basis for viscosity in capillary viscometers. If the differential pressure \( p \) is generated by a height gradient \( h \), and which depends on the flowing liquids, hence: \( \nu_i = \frac{\text{density}}{\text{viscosity}} \), it is measured run of a defined fluid. In the case of very short times, the non-dissipated kinetic energy must be taken into consideration (kinetic energy / Hagenbach correction).

Huggins formula (IV value according to Huggins)

Serves the purpose of the approximate calculation of the intrinsic viscosity of polyolefinic and others, for example: \( K_{iv} \) is an additional constant dependent on polymer.

\[ \nu_i = \frac{1}{\eta_i} \frac{1}{\nu_{rel} - 1} \]

Inherent viscosity

(Staudinger index, intrinsic viscosity)

Is the natural logarithm of the relative viscosity based on concentration \( C \) of the dissolved substance \( \nu_{rel} = \frac{\nu_c}{\nu} \). Unit: \( \text{cm}^3/\text{g} = 100 \text{ dl/g} \)

Intrinsic viscosity

(Staudinger index, intrinsic viscosity)

Is the limiting value of the reduced/inherent viscosity for the case of infinitely severely diluted solvents at disappearing shearings strengths:

\[ \nu_i = \lim_{c \to 0} \nu_{rel} = \lim_{c \to 0} \nu_{rel} \]

It is determined by measuring the \( \eta_{rel} \), as a function of the concentration and extrapolation on \( C \rightarrow 0 \). For many polymers, there are approximation conditions based on the measurement of only one concentration usually specified in standards.

Kinematic viscosity

Describes the quotients of the dynamic viscosity by the density: \( \nu_i = \rho/\eta = \frac{1}{\eta} \) and has the unit \( \text{mm}^2/\text{s} \) (formerly: centistokes, cSt).

Kinetische energy correction: (Hagenbach correction)

If, in the case of short rundown times, there is a necessary correction of the Hagenbach-Poiseuilles Law, then it takes into consideration the kinetic energy not converted into friction warmth in a capillary viscometer:

\[ \nu_i = \frac{1}{\eta} \sqrt{K \cdot \nu \cdot \Delta \tau} \]

Comcorrection factor according to Hagenbach

\[ \Delta \tau = \frac{E}{K \cdot \nu} \]

Comcorrection factor ISO 1628/6:

\[ \Delta \tau = \frac{E}{K \cdot \nu} - \nu \]

K value (according to Fickentcher)

A traditionally-used relative mass for the mole masse for PVC and PIA.\n
\[ K = \frac{1}{\nu_i} \frac{1}{\nu_{rel} - 1} \]

Specific viscosity (relative viscosity increase) \( \nu_i = \nu_{rel} - 1 \)

Viscosity

Properties of a substance (in this case: of liquids) to flow and become irreversibly deformed under the influence of a stress. Flow energy is converted into warmth.

Viscosity index (for mineral oil products)

Is calculated from the viscosities measured at two different temperatures (40 and 100 °C) according to ISO 2909 and ASTM D 2270. Is a standard for the thermal behaviour of various oils. The higher the viscosity index of an oil is, the less it changes its viscosity at various temperatures.

Martin formula (IV value according to Martin)

Serves the purpose of the approximate calculation of the intrinsic viscosity of celluloses and others. As \( K \) is an additional constant dependent on polymer:

\[ \log \nu_i = \log \nu_{rel} + k \cdot v \]

Reduced viscosity (viscosity coefficient)

Is the specific viscosity based on the concentration \( C \) of the dissolved substance:

\[ \nu_{rel} = \frac{1}{\nu} \frac{1}{\nu_{rel}} \]

Relative viscosity

Is the ratio of the dynamic viscosity \( \eta \) of the solvent to that of the solvent \( \eta_s \). In the case of severely diluted solvents, this corresponds almost to the ratio of the kinematic viscosities:

\[ \eta = \frac{\eta_i}{\eta} \]

Schulz-Blaschke

(IV value according to Schulz-Blaschke)

Serves the purpose of the approximate calculation of the intrinsic viscosity of celluloses, polyolefines and others. \( K \) is an additional constant dependent on polymer:

\[ \nu_i = \frac{1}{\eta} \sqrt{K \cdot \nu \cdot \Delta \tau} \]

Somo-Canuta formula

(Somocanuta-Cita)

Serves the purpose of the approximate calculation of the intrinsic viscosity of PMMA and others. No additional polymer characteristic data required.

\[ \nu_i = \frac{1}{\eta} \sqrt{K \cdot \nu \cdot \Delta \tau} \]

Specific viscosity (relative viscosity increase) \( \nu_i = \nu_{rel} - 1 \)

Viscosity

Properties of a substance (in this case: liquids) to flow and become irreversibly deformed under the influence of a stress. Flow energy is converted into warmth.