The right temperature worldwide

LAUDA Measuring instrumentation:

Viscosity measuring system PVS

Company history

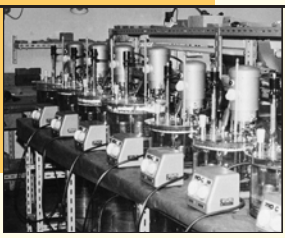
1956

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

1958

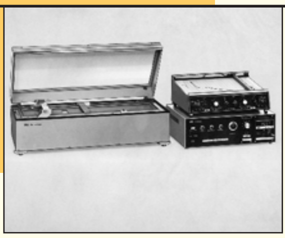
Development of new types of laboratory thermostats in a modular system and development of cooling thermostats with machine cooling.

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).

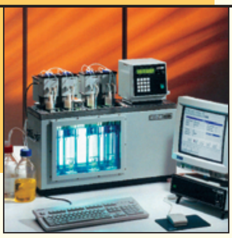
1989

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 is the case with conventional viscometers.

2005

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

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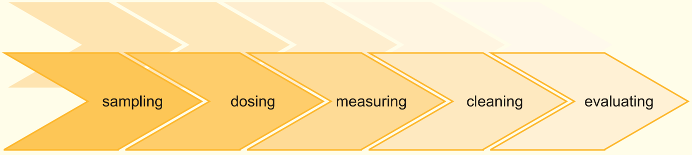
Modularity, the basic principle

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.

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.*

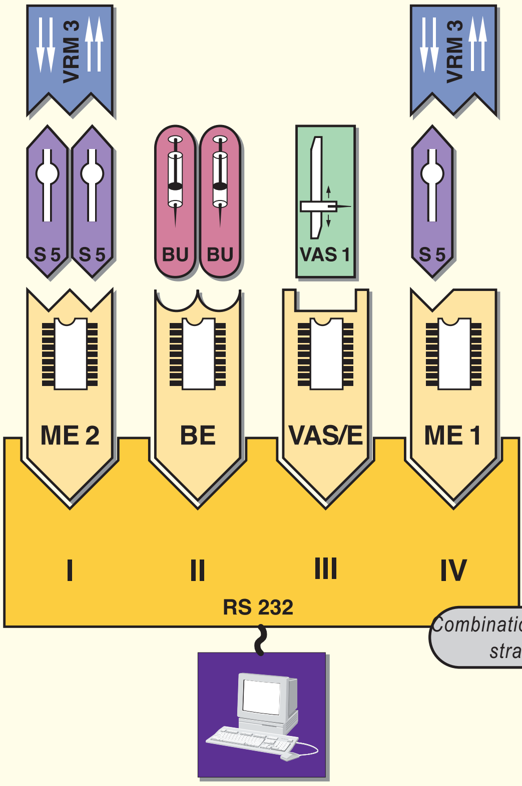
Lubricants, oil and fuel: *measuring viscosity and its variation with temperature as well as viscosity indexes of mineral oil products, additives and their mixtures according to ASTM and ISO standards.*

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.*

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.

Module adjustment to application



Combination of modules (for demonstration purposes only)

Flexibility

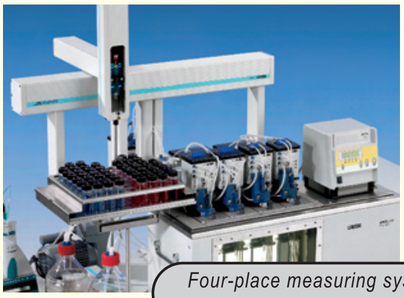
- Individual combination of components to suit the current task
- No ballast through unnecessary functions
- Readily extended at any time
- Always the latest version by integrating newly developed modules

Functionality

- Decentralized arrangement
- Independent intelligent components through single chip processors
- Simple and reliable operation
- Long life, all functional components have maximum resistance to chemicals and heat

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-automatic 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.

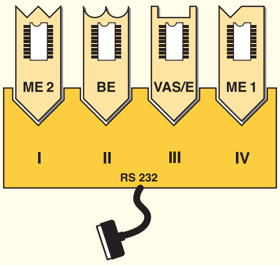
Two-place measuring system PVS 1/2 VRM with ECOLINE Staredition E 215 T



Four-place measuring system with autosampler VAS 1/4

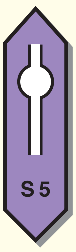
Modules at a glance

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.



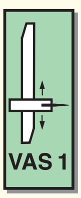
Control unit PVS 1

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.

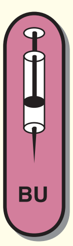


Autosampler VAS 1

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.

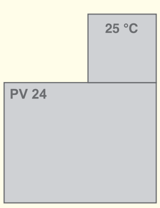
Cleaning module VRM

provides fully automatic cleaning and drying of the viscometers. Either one or two viscometers can be connected and two different cleaning liquids can be selected separately. Even very hot samples up to 180 °C (VRM 3D/HT) and high viscous samples (VRM 3D/HV) can be handled reliably. Use of high-grade materials ensures absolute chemical resistance.



Dosing system

dosimat 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.

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.

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 from closed reservoirs which are mounted on a sample stand with optional thermostating capability. The syringe is automatically cleaned to prevent carry-over of a previous sample or cleaning solvent into the sample on test, a common danger with the more usual fixed tubing connections. The result is an appreciable improvement in reproducibility and accuracy. Before dosing the next sample, the VRM modules ensure thorough cleaning and drying of viscometers and dosing syringe.

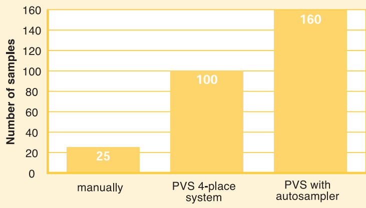
The sequence of the individual tests and the sample assignment are determined by the PC or can be conveniently set by the user.

Efficiency

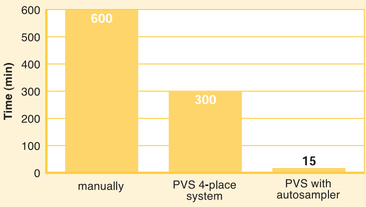
- Automation of time-consuming, labour-intensive manual operations
- Very large sample throughput
- Daily capacity can be accurately predicted

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



Time actually used by operator

Software

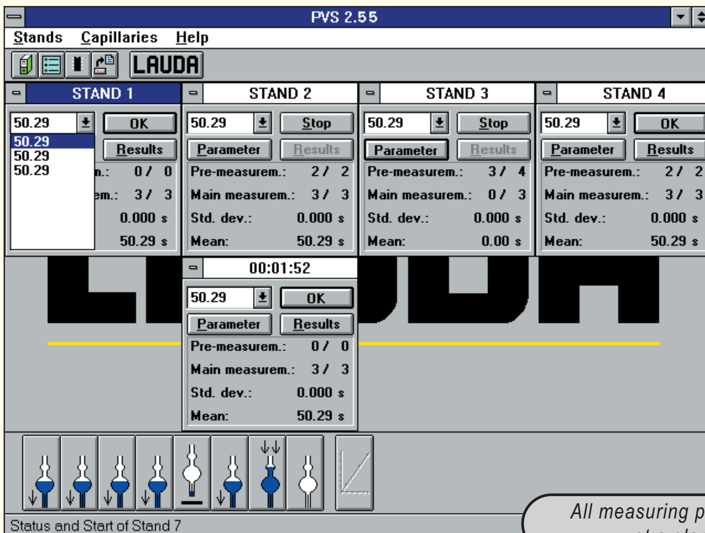
All PVS system configurations are operated via an interface by a conventional PC. The powerful and user-friendly PC program in its standard version also performs all necessary calculations for determining kinematic, dynamic, relative, reduced and inherent viscosity as well as the K-value, completely auto-matically 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 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 1628/6
  - absolute kinematic viscosity
  - absolute dynamic viscosity
  - relative viscosity
  - reduced viscosity (viscosity number)
  - inherent viscosity (logarithmic viscosity number)
  - K-value after Fickentscher

The program provides extensive user support. All parameters are input on the PC by mouse click and keyboard and are transferred to the PVS system via the interface.



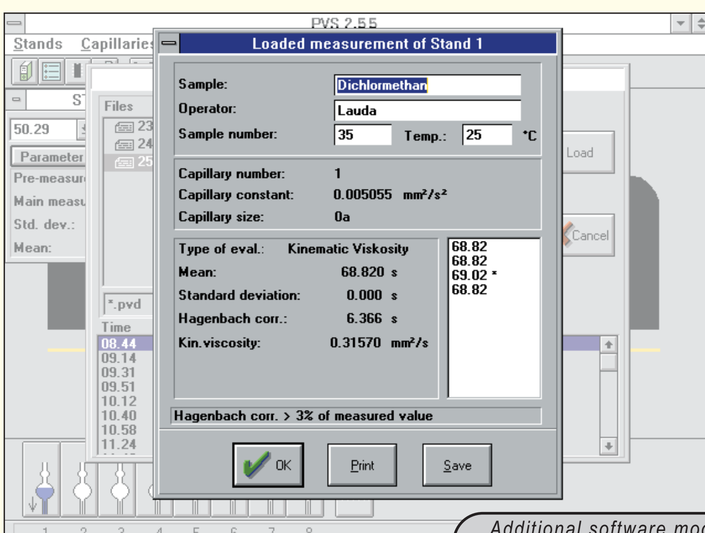
All measuring parameters at a glance

Measurements can be printed in the form of a test protocol and stored in a file in ASCII format. The protocol covers all measurements of the day in chronological order and stores them in a file identified by date. The data can be viewed at any time, ensuring uninterrupted documentation. Further processing with other programs, such as MS Excel, and networking are readily available.

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 2909, ASTM 2270, 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 215 T, PV (L) 15*, PV (L) 24* and PV 36*)

*is adapted with RS 232 interface LRZ 913

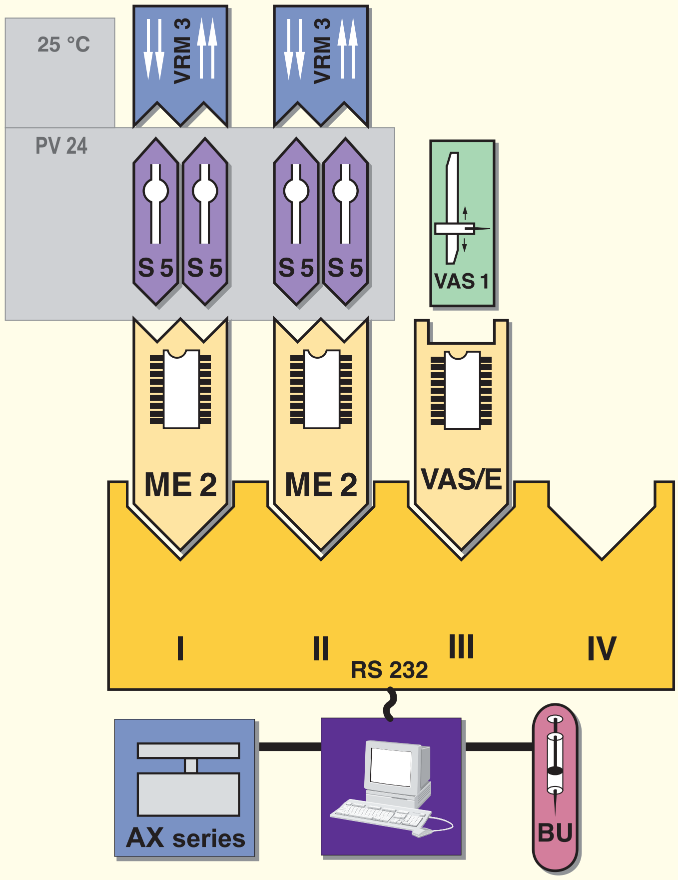


Additional software modules obtain further substance characteristics

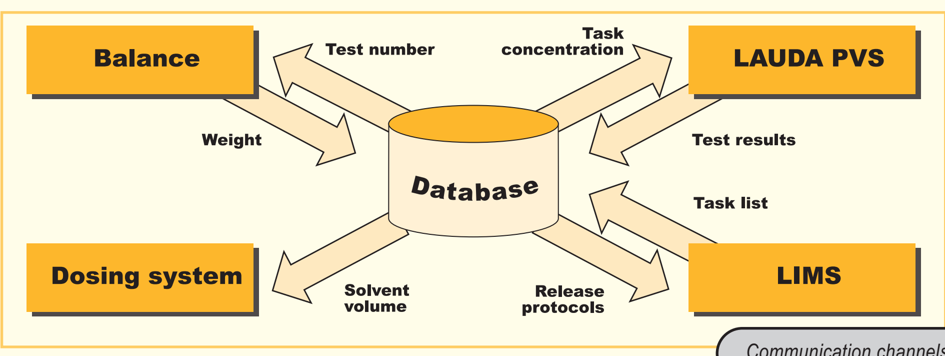
Good laboratory practice requires extensive independence of the measuring conditions by the operating staff. This means that as far as possible no critical measurement parameters such as for example sample descriptions and concentrations can be entered unmonitored. If inputs are required, these must 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.

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 with-out 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.



Example equipment
- Autosampler VAS 1/4 (complete)
- Analytic balances
- Burette 765
- LIMS software module (as per user specification)
- Stirrer block MRH 15



Communication channels

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

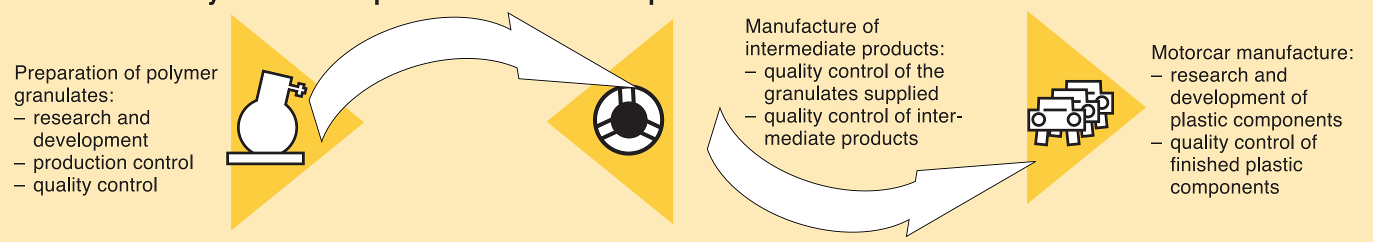
Solvent viscosity of plastics

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 taylor-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



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*
- *Martin method*
- *Maron method*

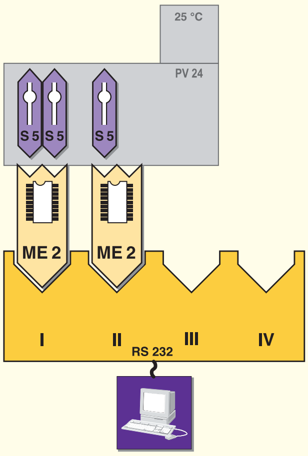
Minimum specification

- 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

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 1601; 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.

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.

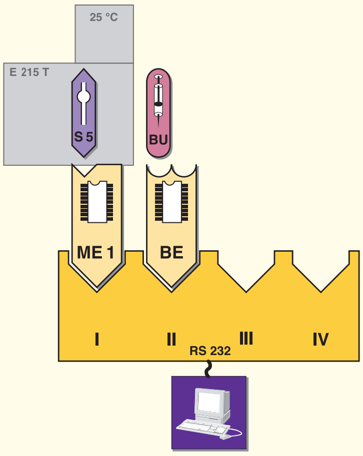


Minimum specification

- Control unit PVS 1/4
- 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

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.

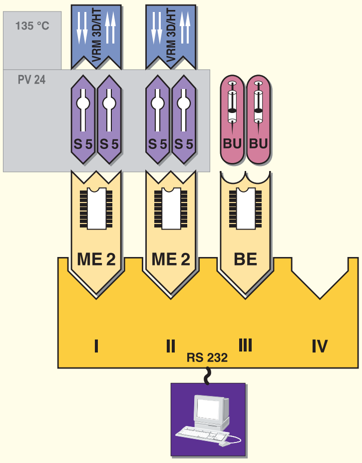


Minimum specification

- Control unit PVS 1/1
- Measuring stand S 5
- Burette module BE and burette
- Ubbelohde dilution viscometer
- Magnetic stirrer
- 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

Measuring system for polyolefines

This configuration permits simple and reliable measurement of the viscosity of polyethylene and polypropylene sulfide solutions at temperatures up to 160 °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.



Typical specification

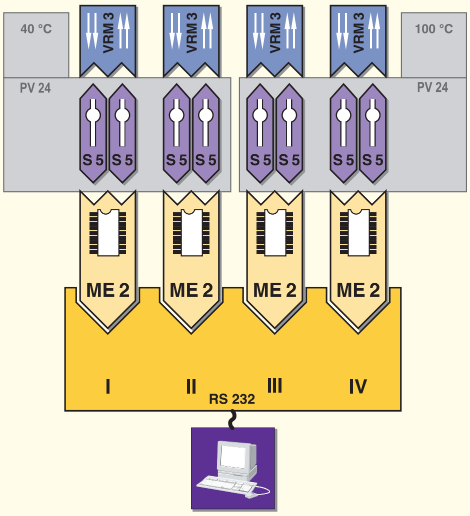
- Control unit PVS 1/4
- 4 Measuring stands S 5
- Burette module BE, 2 burettes
- 4 Ubbelohde dilution viscometers with integrated filters
- 2 Cleaning modules VRM 3D
- 2 temperable valve units UD 651
- 1 pump VRP
- PC with software module INV-DLL
- Thermostat PV 24 with cover plate D 20 V
- 4 Magnetic stirrers fitted in PV 24

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.

Wide temperature ranges

Viscosity index

- Control unit PVS 1/8
- 8 Measuring stands S 5
- 8 Viscometers with aspirating tube (e.g. Cannon-Fenske routine)
- 4 Cleaning modules VRM 3
- PC with software module VID-DLL
- 2 Thermostats PV 24, for 40 and 100 °C each, plus cover plate D 20 V



Viscosity index

Mineral oil production involves regularly repeated measurements to determine and monitor viscosity and its variation at different temperatures. The software module VID-DLL provides a very efficient means for calculating the viscosity index. With one thermostat, the necessary measurements at 40 and 100 °C are performed after a temperature change. The method becomes particularly fast by using measuring stands in two thermostats where measurements at 40 and 100 °C are made almost simultaneously. With eight places and four thermostats, a single procedure permits extremely convenient measurement of viscosities over a large temperature range of, for example, -20, 20, 40 and 100 °C.

Example of system for low-temperature viscosity down to -40 °C

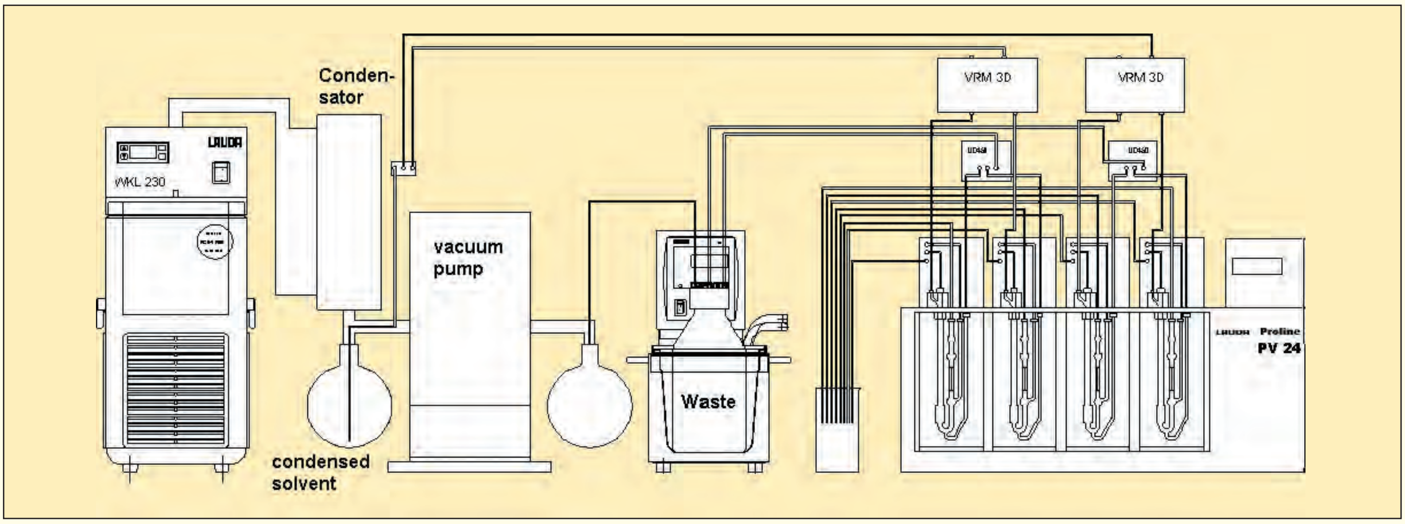
- Control unit PVS 1/2
- 2 Measuring stands S 5
- Cleaning module VRM 3
- 2 Viscometers with aspirating tube (e.g. KPG Ubbelohde)
- PC
- Thermostat PVL 15 with cover plate D 15 V
- Through-flow cooler DLK 45 LiBus plus cold trap
- TEMP-DLL

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.

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.

Easy solvent handling



For this a PVS system with rinsing modules VRM 3D/HV 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.

Example of a 4-place system including solvent recycling

- Control unit PVS 1/4
- 4 Measuring stands S 5
- 4 Ubbelohde with viscometer aspirating tube
- Thermostat PV 24 with coverplate D 20 V
- 2 Rinsing modules VRM 3D/HV
- Controlled vacuum pump with condensers
- PC
- Heating thermostat E 103
- Circulation chiller WKL 230

		Dichlormethane	Acetone	Chloroform	Ethylalcohol
Boiling point	C°	40.0	56.5	61.0	78.5
Temperature of cooler	C°	-10.0	-10.0	-10.0	-10.0
Temperature in evaporation bath	C°	51.6	75.9	82.0	95.5
Vapor pressure	hPa	350.0	350.0	230.0	200.0
Evaporation time	min/100 ml	4.8	3.3	3.0	3.0
Mass loss per cleaning	%	5.0	5.0	6.0	5.0

Determining enzyme activity

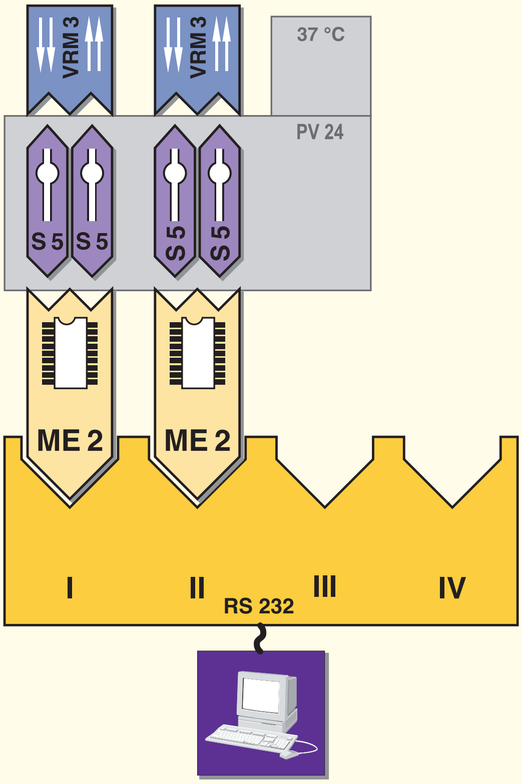
Solutions of certain biological macromolecules alter their viscosity under the influence of enzymes as these effectively cut the dissolved molecular chains. Such situations permit very accurate evaluation of enzyme activity by measuring the variation of relative viscosity during the course of the enzyme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

Example of a system

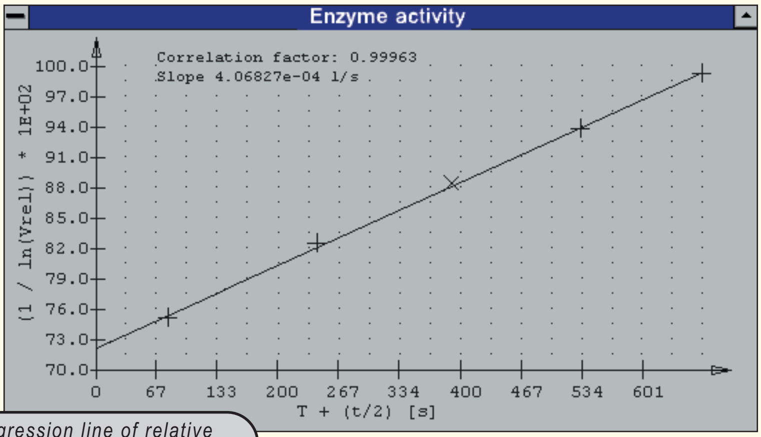
- Control unit PVS 1/4
- 4 Measuring stands S 5
- 4 Ubbelohde viscometers with aspirating tube
- 2 Cleaning modules VRM 3
- PC with software module ENZ-DLL
- Thermostat PV 24 with cover plate D 20 V
- Through-flow cooler DLK 10 or cooling water connection



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 determin the reacting half-life.

Features

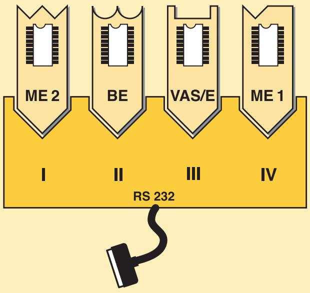
- Up to 99 individual measurements, cover of changes over a wide range of time
- Depending of system up to 8 measurements in parallel
- Reaction start (determined by mixing of solution) can be transferred by key stroke
- Setting of delay time and automatically start of measurements



Regression line of relative viscosity against reaction time

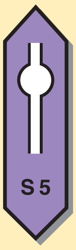
Modules

PVS control units PVS 1		PVS 1/1...1/8
Max. number of places		1...8
PC interface		RS 232 C
Dimensions (WxDxH)	mm	340x270x105
Weight (net)	kg	4.6
Ambient temperature	°C	10...45
Total loading	kW	0.1
Supply	V; Hz	90–240; 50/60



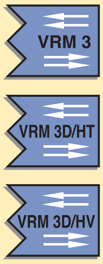
Measuring stands		S 5
Meniscus detection		optical (infrared)
Light detector control		digital (µP)
Sample temperature range	°C	65...180*
Timing range	s	0...9999,99
Recommended flow timing range	s	30...1000
Viscosity range	mm²/s	0.3...50000
Timing resolution	s	0.01
Timing accuracy	ppm	1
Dimensions (WxDxH)	mm	90x90x500
Weight (net)	kg	4.5

*higher temperatures to special order



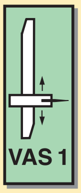
Rinsing modules		VRM 3	VRM 3D/HV	VRM 3D/HT
Sample temperature range	°C	40...100	40...100	20...165*
Viscosity range	mm²/s	0.3...100**	0.3...1000**	0.3...100**
Max. number of solvents		2	1	1
Dimensions (WxDxH)	mm	140x120x125	140x120x125	140x120x125
Weight (net)	kg	4.8	4.6	4.6

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



Autosampler		VAS 1
Sample temperature range	°C	20...135*
Viscosity range	mm²/s	0.3...100
Syringe volume	°C	5
Max. number of samples (50 ml)		35/24
Max. number of samples (25 ml)		63/43
Max. number of places		2/4
Dimensions (WxDxH)	mm	1200x600x1200**
Weight (net)	kg	64**

*thermostated syringe and sample stand with thermostat option
**complete system VAS 1/2 or VAS 1/4 with thermostat PV 24



Control unit PVS 1	
Type	**Cat. No.**
PVS 1/1 incl. 1x ME 1 (for 1 place)	**LMV 816**
PVS 1/2 incl. 1x ME 2 (for 2 places)	**LMV 812**
PVS 1/4 incl. 2 x ME 2 (for 4 places)	**LMV 813**
PVS 1/6 incl. 3 x ME 2 (for 6 places)	**LMV 814**
PVS 1/8 incl. 4 x ME 2 (for 8 places)	**LMV 815**
Each version includes	
Windows software	**LDVM 4014**
RS 232-cable for PC	**EKS 037**
Plug-in extension cards	
2-place measurement module (ME 2) (for up to 2 places)	**LMVZ 930**
Burette module (BE) (for up to 2 burettes 665)	**LMVZ 932**
Magnetic stirrer control module (for max. 4 stirrers) MRE	**LMVZ 966**
Port control module (VAS/E) (in connection to the VAS autosampler)	**LMVZ 943**

Autosampler VAS 1 and accessories	Cat. No.
Two-placesystem with Autosampler VAS 1/2 with software incl. PVS 1, 2 measuring stands S 5 cover plate for PV 24	**LMV 818**
Four-placesystem with Autosampler VAS 1/2 incl. PVS 1, 4 measuring stands S 5 cover plate for PV 24	**LMV 819**
Essential accessories	
Syringe Wash station 4 for VAS 1 (with one rinsing bottle)	**LMVZ 970**
Syringe Wash station 5 for VAS 1 (with two rinsing bottles)	**LMVZ 971**
Syringe Wash station 3 for VAS 1 (for hot solutions with one rinsing bottles)	**LMVZ 972**
Connecting set 3 for viscometers with aspiration tube	**LMRZ 911**
Connecting set 5 for viscometers without aspiration tube	**LMRZ 914**
Connecting set 7 for automatic dilution	**LMRZ 921**
Sample rack PG 50, not heated (for 35 x 50 ml flasks, EG 062)	**LMVZ 939**
Sample rack PG 30, not heated (for 63 x 30 ml flasks)	**LMVZ 947**
Mounting set for stirrer block MRH 15	**LMVZ 969**
Sample rack PGH 24 (heated, max.160°C) (for 24 x 50 ml flasks, EG 062)	**LMVZ 946**
Flasks (50 ml), with GL32 thread for PG 50	**EG 062**
Filter element for EG 062 (1 for each EG 062)	**LMVZ 958**
Coupling cap (1 x for each EG 062 necessary)	**EZV 100**
Sealing rings (50 pieces) for EZV 100	**EDF 122**
Aluminium-plates (à 1000 pieces) for EG 062	**EDF 093**
Flasks (30 ml), with GL32 thread for PG 30	**EG 066**

Autosampler VAS 1 and accessories	Cat. No.
Essential accessories	
Coupling cap (1 x for each EG 066 necessary)	**EZV 104**
Sealing rings (50 pieces) for EZV 104	**EDF 124**
Aluminium-plates (à 1000 pieces) for EG 066	**EDF 092**
Operating unit for VAS	**EBE 038**
Dosing syringe for VAS 1 (only spare part)	**UD 442**
Dosing syringe to be used with LMVZ 958	**UD 556**
Heating block for dosing syringe	**EBE 037**
Vacuum pump (controlled)	**LMVZ 157**

Software and accessories for sample preparation	
Type	**Cat. No.**
Analytic balance	**EBK 006**
Burette 765 (fully automatic)	**EBK 003**
Stirring block MRH 15 (for 100 ml flasks)	**EBK 010**
Adapter rings for 50 ml flasks	**EG 062**
Connecting cable for Burette 765	**UK 253**
Software with own data base	**LDVM 4022**
Software for customers data base, e.g. LIMS-systems.	**LDVM 4023**

Measuring stands	Cat. No.
Measuring stands S 5 (incl. cable and tubing)	**LMVZ 948**
PC and accessories	**On request**
Software modules	
Software module INV-DLL (intrinsic viscosity)	**LDVM 4015**
Software module VID-DLL (viscosity index to ISO 2909)	**LDVM 4016**
Software module ENZ-DLL (enzyme activity)	**LDVM 4017**
Software module TEMP-DLL (temperature control and dependence)	**LDVM 4023**
Dosing system	
Burette 765	**EBK 003**
Burette set 1 for operation without VRM (for 1 burette and 1 viscometer)	**LMVZ 931**
Burette set 2 for operation with VRM (for 1 burette and up to 2 viscometers)	**LMVZ 937**
Additional accessories	
Draining rack (for filling and drying)	**UU 004**
Bottle	**LMVZ 934**
Connecting cap, small, silicone	**HKA 001**
Connecting cap, large, silicone	**HKA 002**
Connecting cap, small, viton	**HKA 147**
Connecting cap, large, viton	**HKA 148**
Connecting cap, large, silicone (for dilution series)	**HKA 118**
Silicon tubes, 3 x 1.5 mm	**RKJ 014**
Viton tube, 3 x 1.5 mm (for sulfuric acid)	**RICJ 020**
Connecting cable burette <-> PVS	**UK 237**
PTFE stirrer	**EZ 195**

Automatic cleaning

VRM 3	
Type	**Cat. No.**
VRM 3 set (for up to 2 measuring stands or syringe wash stations)	**LMR 909**
Standard parts	
Cleaning module VRM 3	**UD 640**
Tubing set 2	**LMRZ 903**
2 connecting caps for glass bottles (GL 45)	**LMRZ 907**
Connecting cable VRM <–> PVS	**UK 230**

Further accessories	Cat. No.
Glass funnel for liquid samples	**EG 060**
Funnel for granulate	**HX 488**
Filter insert for filter EG 060	**UD 410**
Filter for solvent	**UD 404**
Glass bottle 1000 ml (GL 45)*	**EG 058**
Glass bottle 2000 ml (GL 45)**	**EG 059**
Glass bottle 5000 ml (GL 45)*	**EG 6064**
Connecting caps for glass bottles (GL 45)	**LMRZ 907**
One way filling syringe (100 pcs)	**LMRZ 918**
Filter for suction	**UD 513**

*recommended for solvent
**recommended for waste

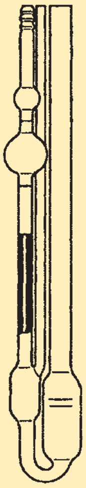
Fixing sets for VRM modules*	Cat. No.
for PV 15 / PVL 15	**LMRZ 904**
for PV 24 / PVL 24	**LMRZ 905**
for PV 36	**LMRZ 906**
for E 215 T* (for 1 VRM)	**LMRZ 908**
for E 215 T* (for 2 VRM)	**LMRZ 916**

*for mounting on a thermostat

VRM 3D/HT · VRM 3D/HV	
Type	**Cat. No.**
VRM 3D set (for max. two measuring stands or syringe wash stations)	**LMR 907**
Standard parts	
Cleaning module VRM 3D	**UD 650**
Valve unit HV (for particle containing or high viscous samples)	**UD 652**
Valve unit HT (for hot samples)	**UD 651**
Tubing set 2	**LMRZ 903**
Connecting caps for glass bottles (GL 45)	**LMRZ 907**
Connecting cable VRM <–> PVS	**UK 230**
Essential accessories	
External vacuum pump VRP (controlled) for up to 3 VRM 3D	**LMRZ 809**
External vacuum pump (not controlled) for up to 3 VRM 3D	**LMVZ 135**
Glass bottle 2000 ml (GL 45)	**EG 059**

Connection sets	Cat. No.
Connecting set 1 (only for viscometers with aspirating tube)	**LMRZ 909**
Connecting set 2 (only for viscometers without aspirating tube)	**LMRZ 910**
Connecting set 6 for autom. dilution	**LMRZ 919**
Connecting set 8 for high viscous samples	**LMRZ 922**

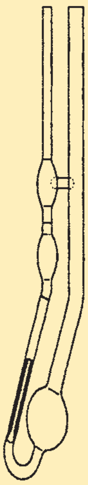
Viscometers for offline cleaning



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.
Also available in ASTM version.

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



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 absolute measurement, for automatic measurement.

Type	K	Cat. No.
25	0.002	**EGV 860**
75	0.008	**EGV 861**
50	0.004	**EGV 862**
100	0.015	**EGV 863**
150	0.035	**EGV 864**
250	0.1	**EGV 865**
350	0.5	**EGV 866**
300	0.25	**EGV 867**
400	1.2	**EGV 878**
450	2.5	**EGV 869**
500	8	**EGV 870**
600	20	**EGV 871**

Micro-Ubbelohde viscometers

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

Type	K	Cat. No.
I	0.01	**EGV 718**
Ic	0.03	**EGV 719**
II	0.1	**EGV 720**
IIc	0.3	**EGV 721**
III	1	**EGV 722**

Micro-Ostwald viscometers

Recommended with pronounced foaming and/or small liquid quantities
Filling volume: 2 ml
Total length: 290 mm approx.
Accuracy: ± 0.2%, calibrated for absolute measurement, for automatic measurement.

Type	K	Cat. No.
I	0.002	**EGV 820**
Ic	0.008	**EGV 821**
II	0.004	**EGV 822**
IIc	0.015	**EGV 823**
III	0.035	**EGV 824**

Viscometer holders and accessories:

Type	Cat. No.
Adapter MUO, required for use of Micro-Ubbelohde or Micro-Ostwald viscometers	**HBK 532**
Ubbelohde viscometer holder*	**UG 003**
Cannon-Fenske viscometer holder*	**UG 084**
Micro-Ostwald viscometer holder*	**UG 094**

*holder fits only LAUDA viscometers

Viscometers for offline cleaning

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.

Type	K	Cat. No.
0	0.0011	**EGV 920**
0a	0.005	**EGV 921**
0c	0.001	**EGV 922**
I	0.01	**EGV 923***
Ic	0.01	**EGV 924**
II	0.1	**EGV 925**

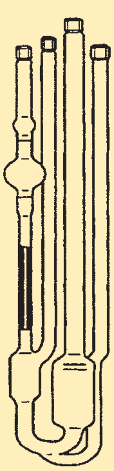
*also available with integrated filter

Calculation formula:

Kinematic viscosity =
viscometer constant (K) x flow time*

**not taken into account Hagenbach correction*

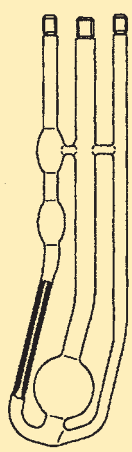
Viscometers for online cleaning



Ubbelohde viscometers

ISO 3105, DIN 51562, BS 188, NFT 60–100.
With filling and cleaning tube
Filling volume: 18...22 ml
Total length: 290 mm approx.
Accuracy: ± 0.1%, calibrated for absolute measurement, for automatic measurement.
Only in conjunction with VRM modules.
Also available in ASTM version.

Type	K	Cat. No.
25	0.002	**EGV 930**
75	0.008	**EGV 931**
50	0.004	**EGV 932**
100	0.015	**EGV 933**
150	0.035	**EGV 934**
250	0.1	**EGV 935**
350	0.5	**EGV 936**
300	0.25	**EGV 937**
400	1.2	**EGV 938**



Cannon-Fenske-Routine viscometers

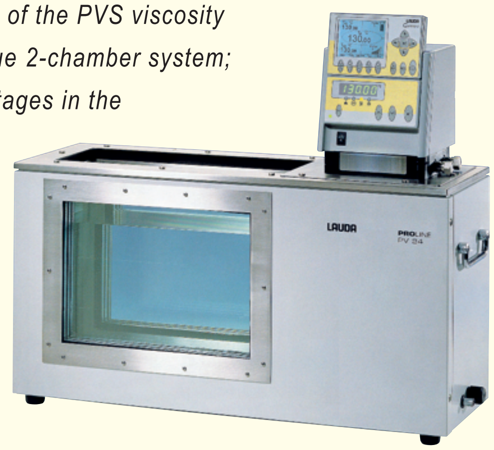
ISO 3105, DIN 51562, BS 188. With filling and cleaning tube
Filling volume: 5..10 ml
Total length: 245 mm approx.
Accuracy: ± 0.2%, calibrated for absolute measurement, for automatic measurement.
Only in conjunction with VRM modules.

Type	K	Cat. No.
25	0.002	**EGV 950**
75	0.008	**EGV 951**
50	0.004	**EGV 952**
100	0.015	**EGV 953**
150	0.035	**EGV 954**
250	0.1	**EGV 955**
350	0.5	**EGV 956**
300	0.25	**EGV 957**
400	1.2	**EGV 958**
450	2.5	**EGV 959**
500	8	**EGV 960**
600	20	**EGV 861**

Clear-view thermostats

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.



		100 °C	with RS 232	230 °C	24 litre	36 litre	-60 °C	-60 °C
Thermostat		**E 115 T**	**E 215 T**	**PV 15**	**PV 24**	**PV 36**	**PVL 15**	**PVL 24**
Working temp. range	°C	20...100	20...100	30...230	30...230	30...230	30...100	30...100
Operating temp. range	°C	-20...100	-20...100	0...230	0...230	0...230	-60...100	-60...100
Temperature stability	± °C	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Resolution of setting	°C	0.1	0.1/0.01	0.1/0.01	0.1/0.01	0.1/0.01	0.1/0.01	0.1/0.01
Resolution of indication	°C	0.01	0.05	0.01	0.01	0.01	0.01	0.01
Safety fittings*		III, FL	III, FL	III, FL	III, FL	III, FL	III, FL	III, FL
Heater power	kW	1.5	2.25	3.5	3.5	3.5	3.5	3.5
Pump								
Type		I-- pressure pump --I						
Pump pressure max.	bar	0.4	0.4	0.8	0.8	0.8	0.8	0.8
Pump flow max. (pressure)	l/min	17	17	25	25	25	25	25
Bath								
Volume	l	10...15	10...15	11...15	19...24	28...36	11...15	19...24
Opening (WxD)	mm	275x130	275x130	230x135	405x135	585x135	230x135	405x135
Bath depth	mm	310	310	320	320	320	320	320
Usable depth	mm	290	290	285	285	285	285	285
Material	mm	I------ polycarbonate ------I		I---------------------------- stainless steel/glass --------------------------------I				
Base area (WxD)	mm	428x142	428x142	506x282	740x282	1040x282	506x282	740x282
Cat. No.		**LCD 0263**	**LCD 0264**	**LCD 0276**	**LCD 0278**	**LCD0280**	**LCD 0282**	**LCD 0284**

*III, FL for use with flammable and non-flammable liquids

For all clear-view thermostats there are various cover plates whose use is strongly recommended.

				Use with		Together with
Type	**Cat. No.**	**No. meas. places**	**No. therm. places***	**PVS without VRM**	**PVS with VRM**	**Comb. No.**
MD 15 V	**LCZ 041**	2	0	●	●	1, 2, 3
MD 15 V/K	**LCZ 040**	1	2	●		1, 2, 3
D 15 V	**LTZ 045**	2	0	●	●	4, 5, 6, 13
D 15 V/K	**LTZ 048**	1	2	●		4, 5, 6, 13
D 20 V	**LTZ 046**	4	0	●	●	7, 8, 9, 14, 16
D 20 V/K	**LTZ 049**	3	3	●		7, 8, 9, 14, 16
D 30 V	**LTZ 047**	6	0	●	●	10, 11, 12

*Thermostating places can be used for preliminary thermostating of filled viscometers in order to save time during measurement. They are only useful if the viscometer is changed for each measurement.

LAUDA through-flow coolers serve as additional coolers in order to cool down heating thermostats or any baths to temperatures below ambient temperature. Through-flow coolers are used mainly for thermostats and are integrated into the cooling circuit. The high-power model DLK 45 LiBus even reaches low temperatures down to -40 °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.

			-15 °C	-30 °C	-40 °C
Through flow coolers			**DLK 10**	**DLK 25**	**DLK 45 LiBus**
Working temperature range		°C	-15...150	-30...150	-40...150
Ambient temperature range		°C	5...40	5...40	5...40
Cooling output at, gross	20 °C	kW	0.25	0.33	1.10
	0 °C	kW	0.20	0.28	0.95
	-10 °C	kW	0.10	0.25	0.85
	-20 °C	kW	––	0.22	0.75
	-30 °C	kW	––	0.20	0.55
	-40 °C	kW	––	––	0.30
Heat exchanger connection			M 16 x 1.13 mm dia. nipple		
Special functions			control connection for 230 V 50/60 Hz		
Overall dimensions (WxDxH)		mm	200x400x320	290x540x330	470x560x430
Weight		kg	17	33	63
Supply*		V; Hz	230; 50/60	230; 50	230; 50
Power loading		kW	0.2	0.5	0.9
Cat.-Nr.			**LFD 010**	**LFD 108**	**LFD 111**

*Protection Class 1 to VDE 0106

Magnetic stirrer sets for determining the intrinsic viscosity by serial regression

Type	Thermostat	Meas. places used	No. dilution viscometers	No. magnetic stirrer sets	Cat. No.
1-place set	E 115 T, E 215 T	1-2	1-2	1-2	**LMZ 841**
2-place fitting set*	PV 15	1-2	1-2	1	**LMVZ 967**
4-place fitting set*	PV 24	1-4	1-4	1	**LMVZ 968**

*built into thermostat, cannot be retrofitted

Type	Cat. No.
Cold Trap (necessary for air-drying at T < 0 °C for connecting to a PVS-System)	**LMRZ 915**
Tubes for connecting thermostat/DLK	
Silicon tube 8 mm i. dia. (9 mm insulated)	**LZS 001**
Silicon tube 11 mm i. dia. (9 mm insulated)	**LZS 007**

Essential accessories:

Type	Cat. No.	Comb.
Connecting cabel	**UK 263**	3, 6, 9, 12 ... 16

Recommended accessories:

Type	Cat. No.	Comb.
Silicone tubing* (per m, min. recommended: 2 m)	**LZS 007**	3, 6, 9, 12 ... 16

*not when using Silicone oil

The table below shows the system combinations for thermostating the viscometers:

				Clear-view thermostats/external baths		Cooling	
Comb. No.	Tmax (°C)	Tmin (°C)	Max. No. places	Type	Cat. No.	Type	Cat. No.
1	100	30	2	E 115 T	LCD 0263	---	---
				E 215 T	LCD 0264	---	---
2	100	20	2	E 115 T	LCD 0263	Tap water	---
				E 215 T	LCD 0264	Tap water	---
3	100	5	2	E 115 T	LCD 0263	DLK 10	LFD 010
				E 215 T	LCD 0264	DLK 10	LFD 010
4	230	30	2	PV 15	LCD 0276	---	---
5	230	25	2	PV 15	LCD 0276	Tap water	---
6	230	10	2	PV 15	LCD 0276	DLK 10	LFD 010
7	230	30	4	PV 24	LCD 0278	---	---
8	230	25	4	PV 24	LCD 0278	Tap water	---
9	230	15	4	PV 24	LCD 0278	DLK 10	LFD 010
10	230	30	6	PV 36	LCD 0280	---	---
11	230	25	6	PV 36	LCD 0280	Tap water	---
12	230	15	6	PV 36	LCD 0280	DLK 25	LFD 108
13	100	-20	2	PVL 15	LCD 0282	DLK 25	LFD 108
14	100	-20	4	PVL 24	LCD 0284	DLK 25	LFD 108
15	100	-40	2	PVL 15	LCD 0282	DLK 45 LiBus	LFD 111
16	100	-40	4	PVL 24	LCD 0284	DLK 45 LiBus	LFD 111

1. All values Tmax and Tmin are based on an ambient temperature of 20 °C.
2. All values for tap water cooling are based on a water temperature of maximal 18 °C.
3. The temperature range Tmin...Tmax usually requires two different bath liquids.

Background illumination and accessories

Type	Cat.-Nr.
AL Atherman lamp 15 (for PV 15 and PVL 15)	**LTZ 001**
AL Atherman lamp 20 (for PV 24 and PVL 24)	**LTZ 002**
AL Atherman lamp 30 (for PV 36)	**LTZ 003**
Filter for thermostating bath	**EG 065**
Flow indicator (necessary when using EG 065)	**EZ 204**
Viscometer holder for 2-legged capillaries (for manual measurement only)	**EZ 054**

21 CFR-11
The guideline 21 CRF, 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.

$$\nu_{int} = \frac{1}{4}\nu_{red} + \frac{3x1n\nu_{rel}}{4C}$$

Dynamic viscosity
Is essential to the shear flows, viscosity coefficient, between shearing strength τ and speed gradient D in $\tau = \eta$ D, and has the unit mPas (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: is internationally valid.

Glass viscometer
Viscometers made from glass, bearing different various designs, stan-dardised in ISO 3105. The most common for automatic measurements is the Ubbelohde version with ventilation pipe.

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

Hagen Poiseuill's Law
(fundamental equation of the capillary viscometry)
This forms the basis for viscometry in capillary viscometers. If the differential pressure is generated by a height difference in front of and behind the capillaries, hence: ν_{kin} = k x t, (k: capillary constant, t: measured run of a defined volume of liquid). 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 polystyrenes and others, for example. K_H is an additional constant dependent on polymer.

$$\nu_{int} = \frac{\sqrt{1+4K_H x\, \nu_{spec}} - 1}{2xCxK_H}$$

Inherent viscosity
(logarithmic viscosity coefficient)
Is the natural logarithm of the relative viscosity based on concentration C of the dissolved substance v_{red} = :ln v_{rel} / C; unit: cm^3/g = 100 dl/g

Intrinsic viscosity
(limiting viscosity number, Staudinger index, IV value)
Is the limiting value of the reduced/inherent viscosity for the case of infinitely severely diluted solvents at disappearing shearing strengths:

$$\nu_{int} = \lim_{C\to 0}\nu_{red} \;/\; \nu_{int} = \lim_{C\to 0}\nu_{inh}$$

It is determined by measuring the v_{red} as a function of the concentration and extrapolation on C = 0. For many polymers, there are approximation conditions based on the measurement of only one concentration usually specified in standards.

Kinematic viscometry
Describes the quotients of the dynamic viscosity by the density: $\nu_{kin} = \eta / \rho$ and has the unit mm^2/s (formerly: centistokes, cst).

Kinetic energy correction: (Hagenbach correction)
If, in the case of short rundown times, there is a necessary correction of the Hagenbach-Poiseuill's Law, and it takes into consideration the kinetic energy not converted into friction warmth in a capillary viscometer.

Corrected viscosity $\nu = k\ x\ (t - \Delta t)$

Correction factor according to Hagenbach $\Delta t = \frac{E}{k\ x\ t^2}$

Correction factor ISO 1628/6: $\Delta t = k / t - \nu_{ref}\ (t)$

K value (according to Fickentscher)
A traditionally-used relative mass for the mole masse for PVC and PVA.

$$K = \frac{a-1+\sqrt{1+\left(\frac{2}{C}+2+a\right)xa}}{150+300C}$$

with: a = 1.5 x logν_{rel}

LIMS
Abbreviation for Laboratory Management System. Describes a system for the control and management of laboratory data, determined by various measuring devices.

Mark-Houwink formula
Provides the relation between medium mole masse (weight means) of the dissolved polymer chains and the intrinsic viscosity. For the absolute mole mass, the proportional constant K and the exponent a can be entered. These depend on the polymer and the solvent, and can be taken from the literature.

$$M = \left(\frac{\nu_{int}}{k}\right)^{\frac{1}{a}}$$

Martin formula (IV value according to Martin)
Serves the purpose of the approximate calculation of the intrinsic viscosity of celluloses and others, e. g. K is an additional constant dependent on polymer.

$$\log\nu_{red} = \log\nu_{int} + kx\nu_{int}\,x\,C$$

Reduced viscosity (viscosity coefficient)
Is the specific viscosity based on the concentration C of the dissolved substance.
v_{red} = : v_{sp} / C; unit: cm^3/g = 100 dl/g

Relative viscosity
Is the ratio of the dynamic viscosity η of the solvent to that of the solvent η_s. In the case of severely diluted solvents, this corresponds almost to the ratio of the kinematic viscosities:
$\nu_{rel} = \eta / \eta_s \approx \nu / \nu_s$

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_1 is an additional constant dependent on polymer.

$$\nu_{int} = \frac{\nu_{red}}{1+K_1 x C x \nu_{red}}$$

Solomon-Ciuta formula
(Solomon-Ciuta)
Serves the purpose of the approximate calculation of the intrinsic viscosity of PMMA and others. No additional polymer characteristic data required.

$$\nu_{int} = \frac{\sqrt{2x\,(\nu_{red}\,x\,C - 1n\,\nu_{rel})}}{C}$$

Specific viscosity (relative viscosity increase)
Is the relative viscosity minus one:
$v_{sp} = v_{rel}$ -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.

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