

LAUDA

truly accurate:

Viscosity measuring system PVS



45 years and more:

Precision from experience

For longer than 45 years LAUDA has been at home in the world of thermostating and measurement technology. LAUDA precision equipments are highly regarded in the most diverse areas of research and industry. Through our world-wide sales and service network we are present in more than 70 countries throughout the world.

Our aim is not only maximum accuracy, technical innovation and long-life products; we also make every effort to develop optimal solutions to the individual requirements of our customers and to be their competent partner. Features such as extensive consultation, simple handling, maximum safety and reliable service are all central to our work.



Innovations

- 1958 ▶ Novel laboratory thermostats of modular construction, low-temperature thermostats with mechanical cooling
- 1964 ▶ The first thermostating equipment for production engineering and manufacture – origin of the Heating and Cooling Systems
- 1967 ▶ Successful start into instrumentation: presentation of an automatic film balance and a ring tensiometer for measuring surface tension
- 1971 ▶ Introduction of the automatic viscometer measuring system, a world-wide first
- 1977 ▶ Second generation of our viscosity systems: VISCOTIMER and VISCOBOY
- 1982 ▶ First thermostat in the world with microprocessor electronics
- 1991 ▶ Another premiere: regular production of the first drop volume tensiometer world-wide
- 1994 ▶ The modular processor-controlled viscosity system PVS with modern WINDOWS software and automatic cleaning
- 1997 ▶ A completely novel energy-saving thermostat concept: the Ecoline
- 1998 ▶ Autosampler VAS 1, the logical step to fully automated viscosity measurement
- 2000 ▶ Introduction of the new generation of Ring/Plate Tensiometer TE 2 at AICHEMA 2000.
- 2001 ▶ The TE 3 with new highly sensitive measurement cell for the highest requirements and new features is developed: e.g. automatic surface cleaning and contact angle determination for fibers.



with the flow:

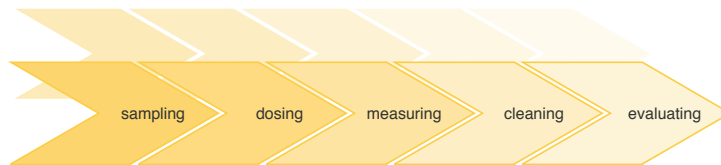
Viscosity

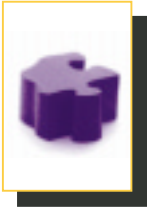
Increasingly stringent quality specifications demand more and more accurate control of raw materials and intermediate products. Kinematic viscosity is an important characteristic of liquids with Newtonian (i.e. ideal) flow behaviour. And capillary viscometry is the most accurate method for measuring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

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 a 1-place measuring system up to 8-place systems with automatic cleaning and the 4-place system with autosampler. 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.





everything open:

Modularity, the basic principle

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.

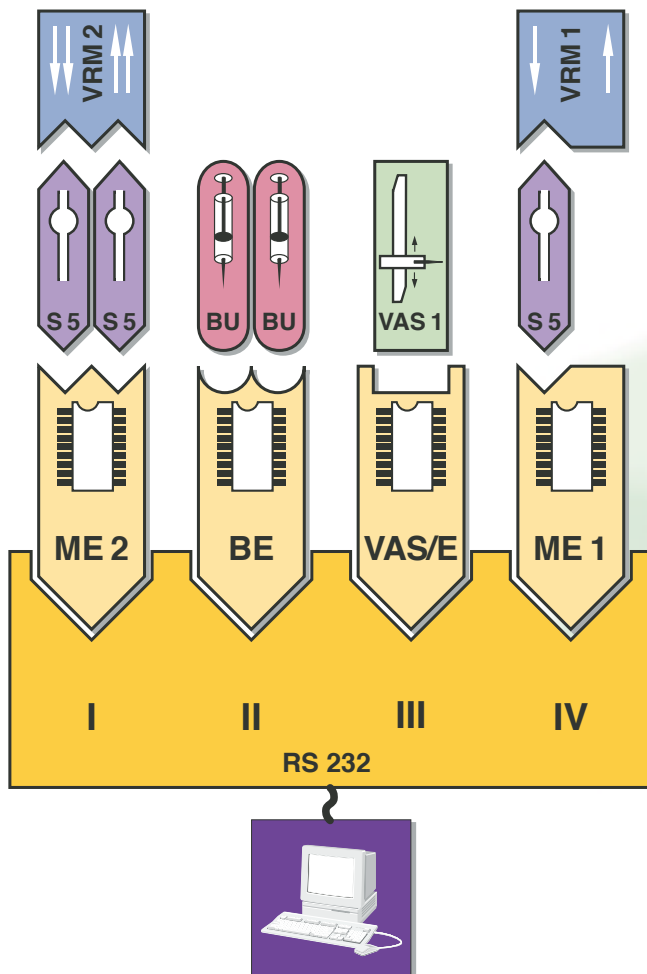
The modular structure also permits economic system arrangements which are optimally matched to actual requirements. The configuration can thus be adapted to a larger sample throughput, to new tasks, or to the integration of newly developed modules.

Flexibility

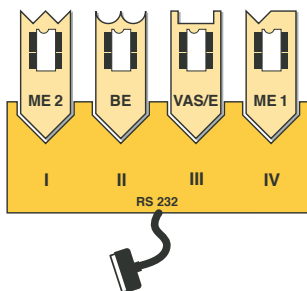
- ▶ Individual combination of components to suit the actual task
- ▶ No ballast through unnecessary functions
- ▶ Readily extended at any time
- ▶ Always the latest version by integrating newly developed modules

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



Combination of modules
(for demonstration
purposes only)



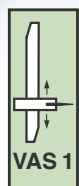
Control unit PVS 1

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).



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.



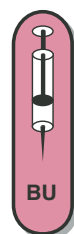
Autosampler VAS 1

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.



Rinsing module VRM

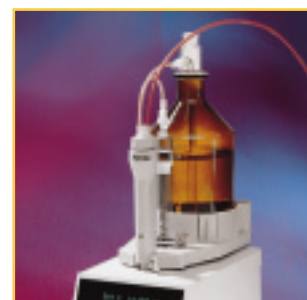
provides fully automatic cleaning and drying of the viscometers. Either one (VRM 1) or two (VRM 2) viscometers can be connected and two different cleaning liquids can be selected separately. Even very hot samples up to 180 °C can be handled reliably (VRM 22/HT). Use of high-grade materials ensures absolute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



Dosing system

burette for determining limiting viscosity through different concentration steps, in conjunction with a dilution viscometer and a magnetic stirrer. Operates from the burette module (BE).

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





fully auto:

The autosampler VAS 1

The VAS 1 autosampler is the ideal modular complement wherever 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 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.

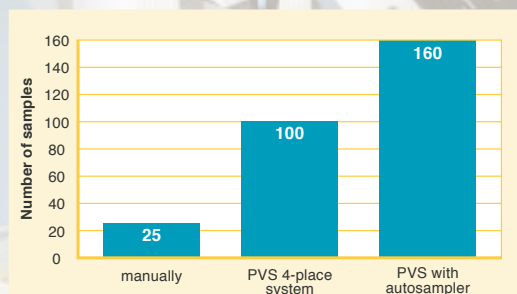
The sequence of the individual tests and the sample assignment are determined by the PC or can be conveniently set by the user.

Efficiency

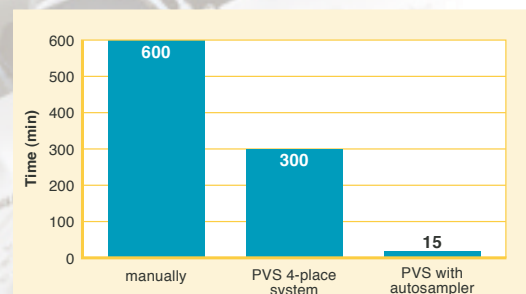
- ▶ Automation of time-consuming, labour-intensive manual operations
- ▶ Very large sample throughput
- ▶ Daily capacity can be accurately predicted

Functionality

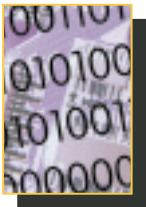
- ▶ Automatic filling of up to four independently operating viscometers
- ▶ Automatic emptying and cleaning with up to two cleaning liquids
- ▶ Facility for mixed operation with two sample types dissolved in different media
- ▶ Operations controlled completely by PC
- ▶ Maximum safety in handling dangerous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



Number of samples handled by one operator in 10 hours



Time actually used by operator



calculable:

Software on Windows basis

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.

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.

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.

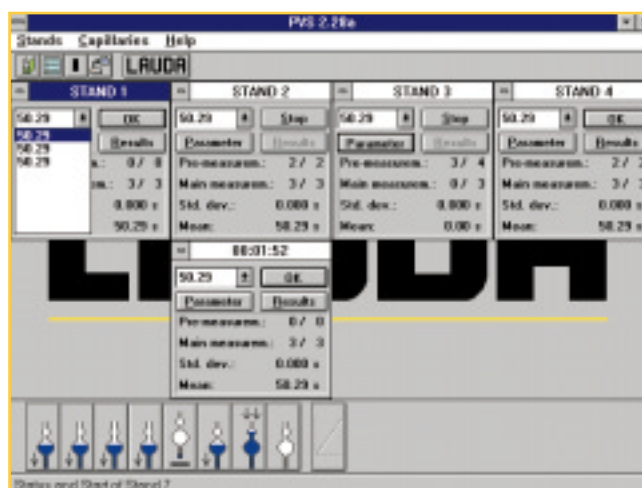
Basic software

▶ 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
- Hagenbach correction (kinetic energy correction)
- ▶ – 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

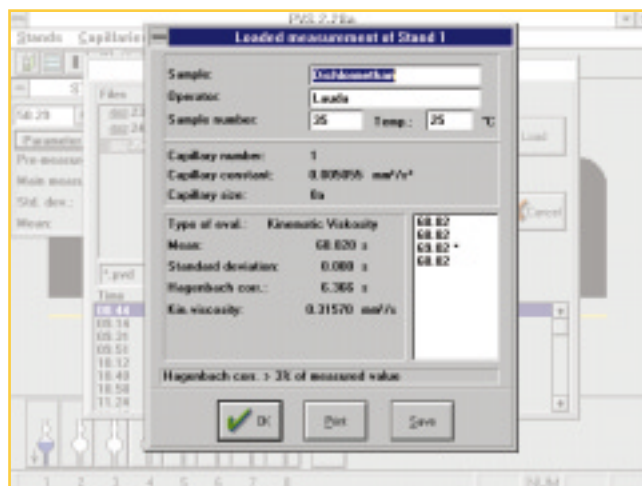
▶ determines the intrinsic viscosity of polymers (limiting viscosity, Staudinger index) and their average molecular weight (chain length)

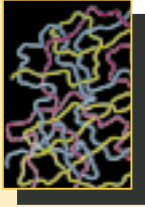
VID-DLL

▶ evaluates the viscosity index of oil according to ISO 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





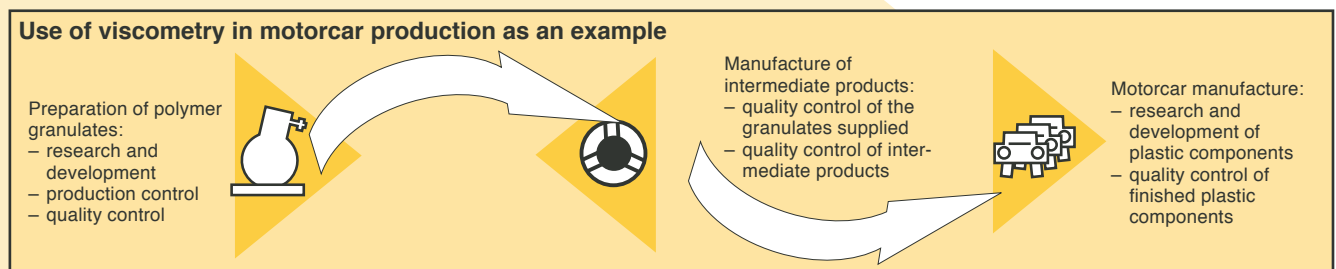
plastics:

Solvent viscosity of polymers

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.

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.

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



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 supported by the module INV-DLL:

- ▶ Point/slope method
- ▶ Schulz-Blaschke method
- ▶ Huggins method
- ▶ Solomon-Ciuta method
- ▶ Billmeyer method
- ▶ Martin method
- ▶ Maron method

Further customized evaluations on request.



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



Compatibility with the laboratory environment

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 LAUDA viscosity measuring system PVS is capable to read in finished lists with all necessary parameters provided by the LIMS; this also applies to concentration entries that can be read in directly from the communications-capable balances and dosing systems. For the information of the user, 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.

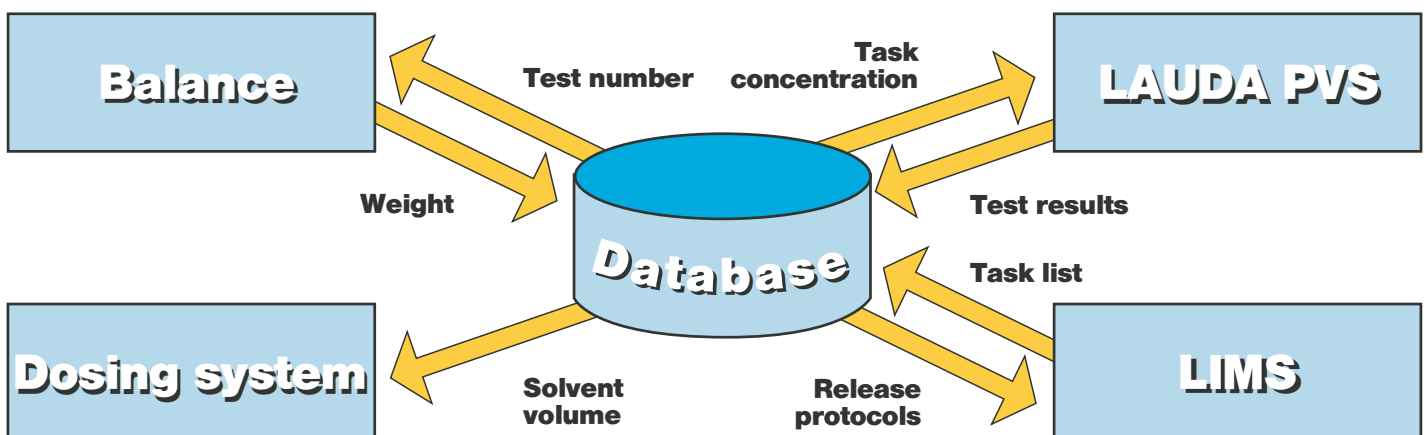
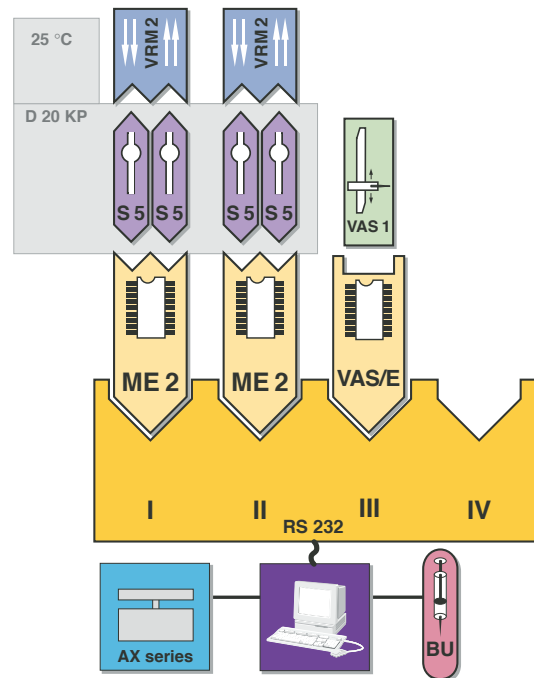
All users must log in with their own account and password and have limited access to the system dependent on the level of authorisation they enjoy. This means that shift staff can only read in finished lists and can activate a series of measurements without needing to make any entries themselves. The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

Example equipment

- ▶ Autosampler VAS 1/4 (complete)
- ▶ Analytic balance AX series
- ▶ Burette 765
- ▶ LIMS software module (as per specification of the user)

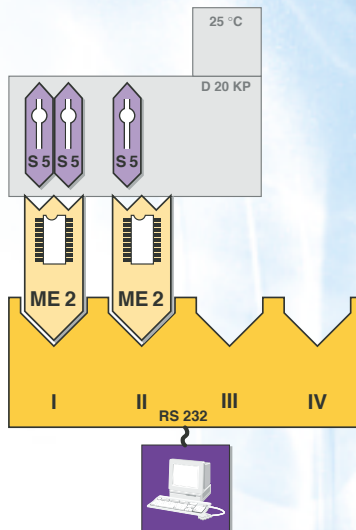
Features

- ▶ 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



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.

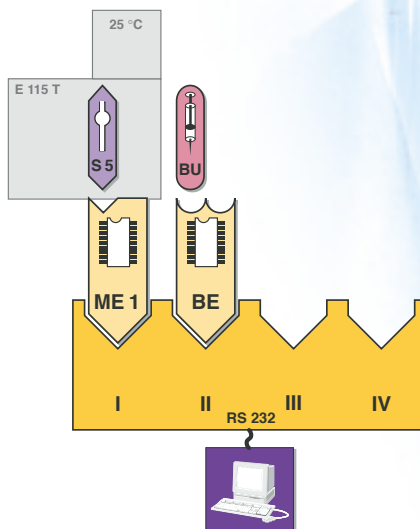


Minimum specification

- ▶ Control unit PVS 1/4
- ▶ 3 Measuring stands S 5
- ▶ 3 KPG Ubbelohde viscometers
- ▶ PC with software modul INV-DLL
- ▶ Thermostat D 20 KP 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.

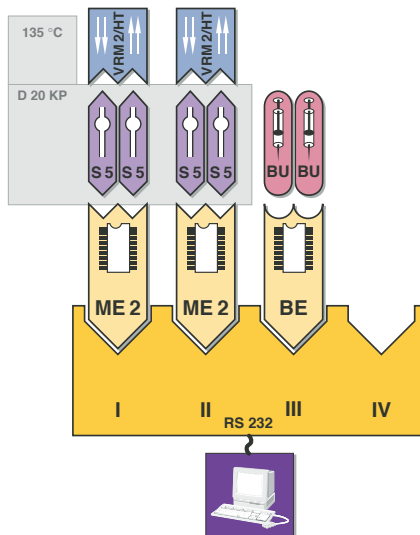


Minimum specification

- ▶ 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

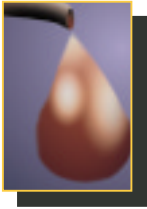
Measuring system for polyolefines

This configuration permits simple and reliable measurement of the viscosity of polyethylene and polypropylene sulfide solutions at temperatures up to 160 °C. Even the previously very difficult evaluation of dissolved polyphenylene sulfide at temperatures above 200 °C can be handled. The sample as granulate or powder is placed directly into the dilution viscometer 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 normally 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
- ▶ 2 Cleaning modules VRM 22/HT
- ▶ PC with software module INV-DLL
- ▶ Thermostat D 20 KP with cover plate D 20 V
- ▶ 4 Magnetic stirrers fitted in D 20 KP



like clockwork:

Testing technical lubricants

Viscosity index

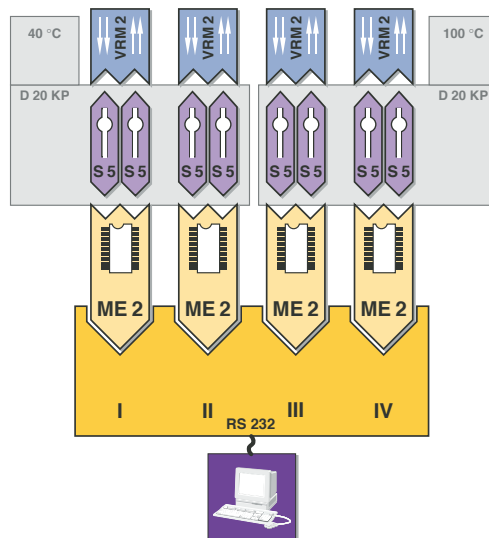
Mineral oil production involves regularly repeated measurements to determine and monitor viscosity and its variation at different temperatures. The software module VID-DLL provides a very efficient means for calculating viscosity index. With one thermostat, the necessary measurements at 40 °C and 100 °C are performed after a temperature change. The method becomes particularly fast by using measuring stands in two thermostats where measurements at 40 °C 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, -40, -20, 20, 40 and 100 °C.

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 -40 °C. In addition to high-power LAUDA refrigeration units and specially insulated clear-view thermostats the method involves a cold trap for air drying.

Complete system for 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 2
- ▶ PC with software module VID-DLL
- ▶ 2 Thermostats D 20 KP, for 40 °C and 100 °C resp., plus cover plate D 20 V



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

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



reaction time:

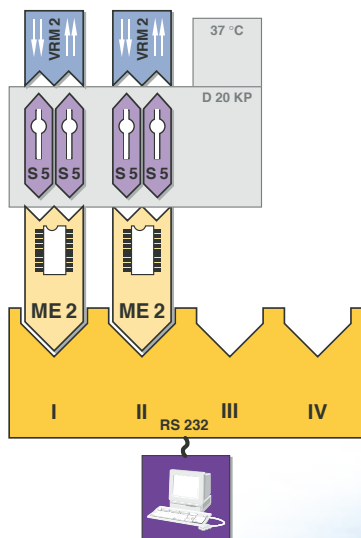
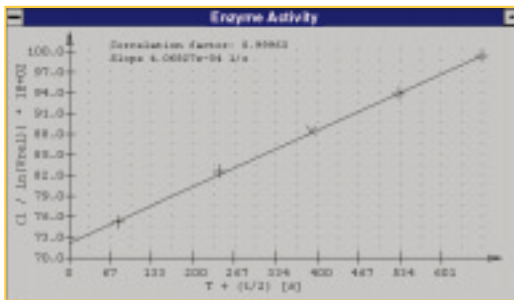
Determining enzyme activity

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.

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.

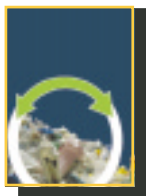
In addition the software module ENZ-DLL provides a graphical representation of the logarithmic relative viscosity against reaction time, draws the regression line through the test points and determines the reaction half-life.

With up to 99 individual measurements the module covers the changes over a wide range of time. Depending on the system, up to 8 measurements can be performed in parallel. The instant of the reaction start, determined by mixing of the solution, can be transferred to the program by a key stroke. Alternatively a delay time can be set on the program after which the program automatically starts the measurements.



Example of a system

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



Disposal problems solved

Integrated solvent recycling

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 the waste bottle and back into the rinsing supply bottle. For this a 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.

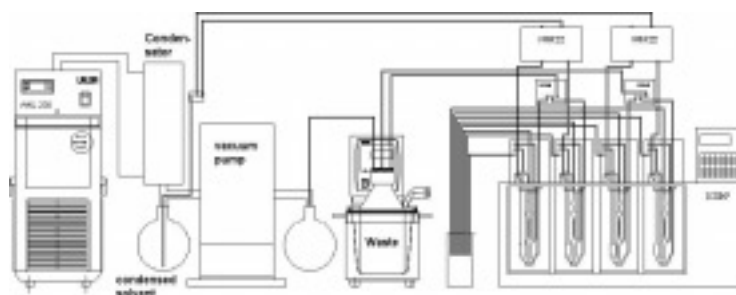
Evaporated solvent passes at the re cooler where it is condensed and returned as purified liquid directly into the rinsing supply bottle: As the pump is used twice to aspirate the viscometer empty and to evaporate the rinsing agent, merely an additional re cooler, and thermostating devices are required 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 D 30 KP with cover plate D 30 V
- ▶ 2 Rinsing modules VRM 22
- ▶ Controlled vacuum pump with condensers
- ▶ PC
- ▶ Heating thermostat E 111
- ▶ Circulation chiller WKL 230

	Dichlormethane	Acetone	Chloroform	Ethyl alcohol
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	95.0
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

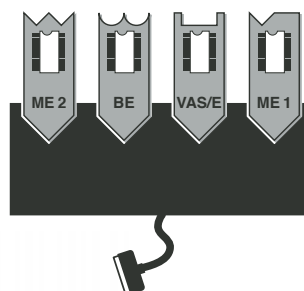


Technical data:

Functional units

PVS 1/1...1/8

PVS control units PVS 1		
Max. number of places		1 ... 8
PC interface		RS 232 C
Dimensions (W x D x H)	(mm)	340 x 270 x 105
Weight (net)	(kg)	4.6
Ambient temperature	(°C)	10 ... 45
Total loading	(kW)	0.1
Supply	(V, Hz)	90–240; 50/60



S 5

Measuring stands

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	(mm ² /s)	0.3 ... 50000
Timing resolution	(s)	0,01
Timing accuracy	(ppm)	1
Dimensions (W x D x H)	(mm)	90 x 90 x 500
Weight (net)	(kg)	4.5

* higher temperatures to special order



VRM 1

VRM 2

VRM 22

VRM 22/HT

Rinsing modules					
Sample temperature range	(°C)	–40 ... 100	–40 ... 100	–40 ... 100	20 ... 165*
Viscosity range	(mm ² /s)	0.3 ... 100**	0.3 ... 100**	0.3 ... 1000**	0.3 ... 100**
Max. number of solvents		2	2	1	1
Dimensions (W x D x H)	(mm)	140 x 120 x 125	140 x 120 x 125	140 x 120 x 125	140 x 120 x 125
Weight (net)	(kg)	4.6	4.8	4.6	4.6

* higher temperatures to special order

** can be extended through special cleaning routines

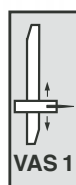


VAS 1

Autosampler		
Sample temperature range	(°C)	20 ... 135*
Viscosity range	(mm ² /s)	0.3 ... 100
Syringe volume	(ml)	5
Max. number of samples (50 ml)		38
Max. number of samples (30 ml)		63
Max. number of places		2/4
Dimensions (W x D x H)	(mm)	1200 x 600 x 1200**
Weight (net)	(kg)	64**

* thermostated syringe and sample stand with thermostat option

**complete system VAS 1/2 or VAS 1/4 with thermostat D 20 KP



Parts and accessories:

Viscosity measurement

Control unit PVS 1

Type	Ref. No.
PVS 1/1 incl. 1 x ME 1 (for 1 place)	LMV 816
PVS 1/2 incl. 1 x 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
Port control module (VAS/E) (for operating the VAS autosampler)	LMVZ 943

Autosampler VAS 1 and accessories

Two-place-system with Autosampler VAS 1/2 with software incl. PVS 1, 2 measuring stands S 5 cover plate for D 20 KP	LMV 818
Four-place-system with Autosampler VAS 1/2 incl. PVS 1, 4 measuring stands S 5 cover plate for D 20 KP	LMV 819

Essential accessories:

Syringe Wash station 1 for VAS 1 (with one rinsing bottle, one VRM 1 module)	LMVZ 941
Syringe Wash station 2 for VAS 1 (with two rinsing bottles, two VRM 1 modules)	LMVZ 951
Syringe Wash station 3 for VAS 1 for hot solutions with one rinsing bottles, one VRM 22/HT module)	LMVZ 953
Connection set 3 for viscometer with aspiration tube consisting of: Set of tubes 1 Automatic sample lock 1	LMRZ 911 LMRZ 902 UD 502
Connection set 5 for viscometer without aspiration tube consisting of: Set of tubes 1 Automatic sample lock 2	LMRZ 914 LMRZ 902 UD 503
Sample rack RG 50, not heated (for 38 x 50 ml flasks, EG 062)	LMVZ 939
Sample rack PG 30, not heated (for 62 x 30 ml flasks)	LMVZ 947

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) f. EG 062	EDF 093
Flasks (30 ml), , with GL32 thread for PG 30	EG 066
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) f. EG 066	EDF 092
Operating unit for VAS	EBE 038
Dosing syringe for VAS 1 (only spare part)	UD 442
Heating block for dosing syringe	EBE 037
Vacuum pump (controlled)	EMP 0137

Software and accessories for sample preparation

Analytic balance AX 204	EBK 006
Burette 765 (fully automatic)	EBK 003
Connection cable for Burette 765	UK 253
Software with own data base	LDVM4022
Software for customers data base, e.g. LIMS-systems.	LDVM4023

Viscosity measurement

Measuring stands

Type	Ref. No.
Measuring stand 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

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 22 (for 1 burette and up to 2 viscometers)	LMVZ 937

Additional accessories

Draining rack (for filling and drying)	UU 004
Bottle	LMVZ 934
Connection cap, small, silicone	HKA 001
Connection cap, large, silicone	HKA 002
Connection cap, small, NBS	HKA 010
Connection cap, large, NBS	HKA 011
Connection cap, large, silicone (for dilution series)	HKA 118
Silicone tubes, 3 x 1.5 mm	RKJ 014
Connection cable burette <-> PVS	UK 237
PTFE stirrer	EZ 195

Parts and accessories:

Automatic cleaning

VRM 1 / VRM 2

Type	Ref. No.
VRM 1 with accessories (for one measuring stand)	LMR 903
VRM 2 with accessories (for max. 2 measuring stands)	LMR 902
Standard parts:	
Rinsing module VRM 1*	UD 380
Rinsing module VRM 2*	UD 333
Tubing set 2	LMRZ 903
2 stopper (for glass bottles GL 45)	LMRZ 907
Connecting cable VRM <-> PVS	UK 230

* depending on version

Additional accessories

Type	Ref. No.
Glass funnel for liquid samples	EG 060
St. steel funnel PVDF for granulate	HX 488
Filter element for funnel 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 (10 pcs)	LMRZ 918
Filter for suction	UD 513

Fixing sets for VRM modules*

Type	Ref. No.
for D 15 KP / DL 15 KP*	LMRZ 904
for D 20 KP / DL 20 KP*	LMRZ 905
for D 30 KP*	LMRZ 906
for E 215T* (for 1 VRM)	LMRZ 908
for E 215 T* (for 2 VRM)	LMRZ 916

* for mounting on a thermostat

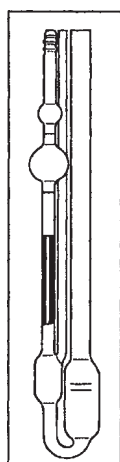
VRM 22/VRM 22HT

Type	Ref. No.
VRM 22 for max. two measuring stands	LMR 906
VRM 22/HT (for hot polymer solutions) for max. two measuring stands	LMR 907
Standard parts:	
Rinsing module VRM 22	UD 484
Valve unit 1 (only at VRM 22) or	UD 460
Valve unit 2 (heated; only at VRM 22/HT)	UD 458
Set of tubes 2	LMRZ 903
2 stopper (GL 45, for glass bottles)	LMRZ 907
Connection cable VRM ÷ PVS 1	UK 230
Essential accessories:	
Vacuum pump (controlled) with re cooler for up to 3 VRM 22	EMP 137
Glass bottle 2000 ml (GL 45)	EG 059

Connection sets

Type	Ref. No.
Connection set 1 (only for viscometers with aspirating tube)	LMRZ 909
Connection set 2 (only for viscometers without aspirating tube)	LMRZ 910
Standard parts connection set 1:	
Set of tubes 1	LMRZ 902
Sample lock 1	UD 500
Standard parts connection set 2:	
Set of tubes 2	LMRZ 912
Sample lock 2	UD 501

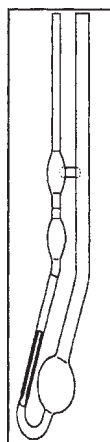
Viscometers for off-line cleaning



Ubbelohde viscometers

ISO-DIS 3105, DIN 51562, BS 188, NFT 60-100
 Filling volume: 15–20 ml
 Total length: 290 mm approx.
 Accuracy: $\pm 0.1\%$, calibrated for absolute measurement, for automatic measurement.
 Also available in ASTM version.

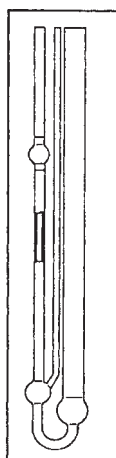
Type	K	Ref. No.
0	0.001	EGV 690
0c	0.003	EGV 700
0a	0.005	EGV 701
I	0.01	EGV 702
Ic	0.03	EGV 703
Ia	0.05	EGV 691
II	0.1	EGV 704
IIc	0.3	EGV 705
IIa	0.5	EGV 692
III	1	EGV 706
IIIc	3	EGV 707
IIIa	5	EGV 693
IV	10	EGV 708
IVc	30	EGV 699
IVa	50	EGV 698



Cannon-Fenske Routine viscometers

ISO-DIS 3105, ASTM D 2515, BS 188
 Filling volume: 5–10 ml
 Total length: 245 mm approx.
 Accuracy: $\pm 0.2\%$, calibrated for absolute measurement, for automatic measurement.

Type	K	Ref. 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
200	0.1	EGV 865
350	0.5	EGV 866
300	0.25	EGV 867
400	1.2	EGV 868
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: $\pm 0.5\%$, calibrated for absolute measurement, for automatic measurement.

Type	K	Ref. 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



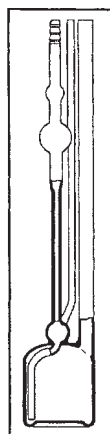
Micro Ostwald viscometers

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

Type	K	Ref. No.
I	0.01	EGV 820
Ic	0.03	EGV 821
II	0.1	EGV 822
IIc	0.3	EGV 823
III	1	EGV 824

Viscometer holders and accessories

Type	Ref. No.
Adapter MUO, required for use of Micro-Ubbelohde or Micro-Ostwald viscometers	HBK 532
Ubbelohde viscometer holder	UG 003
Dilution viscometer holder	UG 098
Cannon-Fenske viscometer holder	UG 084
Micro-Ostwald viscometer holder	UG 094



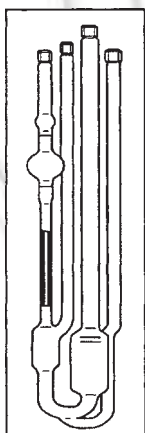
Dilution Ubbelohde viscometers

for determining the intrinsic viscosity
 Filling volume: 15–75 ml
 Total length: 290 mm approx.
 Accuracy: $\pm 0.1\%$, uncalibrated, for automatic measurement.

Type	K	Ref. No.
0	0.001	EGV 920
0a	0.005	EGV 921
0c	0.003	EGV 922
I	0.01	EGV 923
Ic	0.03	EGV 924
II	0.1	EGV 925

Parts and accessories:

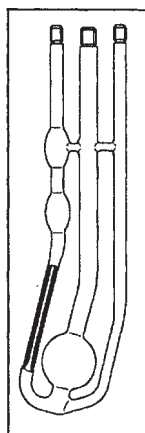
Viscometers for on-line cleaning



Ubbelohde viscometers

ISO-DIS 3105, DIN 51562, BS 188, NPT 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	Ref. No.
0	0.005	EGV 930
0c	0.003	EGV 931
I	0.01	EGV 932
Ic	0.03	EGV 933
II	0.1	EGV 934
IIc	0.3	EGV 935
III	1	EGV 936
IIIc	3	EGV 937
IV	10	EGV 938



Cannon-Fenske Routine viscometers

ISO-DIS 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	Ref. 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
200	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 961

Calculation formula:

$$\text{Kinematic viscosity} = \text{viscometer constant (K)} \times \text{flow time}^*$$

* no allowance for Hagenbach correction

Clear-view thermostats:

Thermostating

	100 °C	with RS 232	230 °C	24 litre	36 litre	-40 °C	-40 °C	-60 °C
Thermostat	E 115 T	E 215 T	D 15 KP	D 20 KP	D 30 KP	DL 15 KP	DL 20 KP	GD 20 KP
Working temp. range °C	20 ... 100	20 ... 100	45 ... 230	40 ... 230	40 ... 230	45 ... 100	40 ... 100	40 ... 100
Operating temp. range °C	-20 ... 100	-20 ... 100	0 ... 230	0 ... 230	0 ... 230	-40 ... 100	-40 ... 100	-60 ... 60
Temperature control ± °C	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Resolution of setting °C	0.1	0.1/0.01	0.01	0.01	0.01	0.01	0.01	0.01
Resolution of indication °C	0.1	0.05	0.01	0.01	0.01	0.01	0.01	0.01
Safety fittings	FL	FL	FL	FL	FL	FL	FL	FL
Heater power kW	1.5	2.25	3.0	3.0	3.0	3.0	3.0	2.0
Pump								
Type	----- pressure pump -----							
Max. pressure bar	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4
Max. flow (pressure) l/min	17	17	18	18	15	18	18	18
Bath								
Volume l	10 ... 15	10 ... 15	13 ... 15	21 ... 24	32 ... 36	13 ... 15	21 ... 24	21 ... 24
Opening (W x D) mm	275 x 130	275 x 130	230 x 135	405 x 135	585 x 135	230 x 135	405 x 135	405 x 135
Bath depth mm	310	310	320	320	320	320	320	320
Usable depth mm	290	290	265	265	265	265	265	265
Material mm	----- polycarbonate -----		----- stainless steel/glass -----					
Footprint (W x D) mm	428 x 142	428 x 142	480 x 220	710 x 220	1010 x 220	480 x 220	710 x 220	710 x 220
Ref. No.	LCD 0263	LCD 0264	LCD 121	LCD 122	LCD 123	LCD 124	LCD 125	LCD 1275

LAUDA clear-view thermostats ensure accurate and reliable thermostating of objects placed into 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 viscometer system. In addition the models series D and DL 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 thermostat E 215 T offers a lower-priced alternative in the temperature range up to 100 °C.



Through-flow coolers:

Thermostating

		-15 °C	-30 °C	-40 °C
Through-flow coolers		DLK 10	DLK 25	DLK 45
Working temperature range	°C	-15 ... 150	-30 ... 150	-40 ... 150
Ambient temperature range	°C	5 ... 40	5 ... 40	5 ... 40
Cooling capacity, gross kW (to DIN 58966T1)	20 °C	0.25	0.33	1.10
	0 °C	0.20	0.28	0.95
	-10 °C	0.10	0.25	0.85
	-20 °C	--	0.22	0.75
	-30 °C	--	0.20	0.55
	-40 °C	--	--	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 (W x D x H)	mm	200 x 350 x 320	290 x 540 x 330	460 x 540 x 400
Weight	kg	17	33	63
Supply (Protection Class 1 to VDE 0106)	V; Hz	230; 50/60	230; 50	230; 50
Power loading	kW	0.2	0.5	0.9
Ref. No.		LFD 010	LFD 108	LFD 109

LAUDA through-flow coolers are accessory units for clear-view thermostats and permit working at ambient temperature and below. The high-power model DLK 45 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.



Equipment combinations:

Thermostating

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

Comb. No.	T _{max} (°C)	T _{min} (°C)	Max. No. places	Clear-view thermostats/ external baths		Cooling	
				Type	Ref. No.	Type	Ref. No.
1	100	30	2	E 215 T	LCD 0264		
2	100	25	2	E 215 T	LCD 0264	Tap water	
3	100	5	2	E 215 T	LCD 0264	DLK 10	LFD 010
4	230	45	2	D 15 KP	LCD 121		
5	230	30	2	D 15 KP	LCD 121	Tap water	
6	230	15	2	D 15 KP	LCD 121	DLK 10	LFD 010
7	230	40	4	D 20 KP	LCD 122		
8	230	30	4	D 20 KP	LCD 122	Tap water	
9	230	20	4	D 20 KP	LCD 122	DLK 10	LFD 010
10	230	40	6	D 30 KP	LCD 123		
11	230	30	6	D 30 KP	LCD 123	Tap water	
12	230	20	6	D 30 KP	LCD 123	DLK 10	LFD 010
13	100	-20	2	DL 15 KP	LCD 124	DLK 25	LFD 108
14	100	-40	4	DL 20 KP	LCD 125	DLK 45	LFD 109
15	100	-15	1	G IV	LCZ 035	RC 6 CS	LCK 170
16	100	-32	1	G IV	LCZ 035	RK 8 KS	LCK 178
17	100	-47	1	G IV	LCZ 035	RL 6 CS	LCK 182
18	100	-60	4	GD 20 KP	LCD 1275	RL 14 CB	LUK 136
19	100	-62	4	GD 20	LTD 107	RUK 90	LUK 205

1. All values T_{max} and T_{min} are based on an ambient temperature of approx. 25 °C.
2. All values for tap water cooling are based on a water temperature of 18 °C.
3. The temperature range T_{min} ... T_{max} usually requires two different bath liquids.

Background illumination

AL 15 (for D 15 KP and DL 15 KP)	LTZ 001
AL 20 (for D 20 KP and DL 20 KP)	LTZ 002
AL 30 (for D 30 KP)	LTZ 003
Filter for thermostating bath	EG 065
Flow indicator (necessary when using EG 065)	EZ 204
Viscometer holder for capillaries, 2-legged (for manual measurement only)	EZ 054



Equipment combinations:

Thermostating

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

Type	Ref. No.	No. meas. places	No. therm. places*	Use with		Together with comb. No.
				PVS without VRM	PVS with VRM	
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, 18
D 20 V/K	LTZ 049	3	2	●		7, 8, 9, 14, 18
D 30 V	LTZ 047	6	0	●	●	10, 11, 12, 18

* 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.

Other accessories:

Thermostating

Magnetic stirrer sets for determining the intrinsic viscosity by serial regression

Type	Thermostat	Meas. places used	No. dilution viscometers	No. magnetic stirrer sets	Ref. No.
1-place set	E 215 T	1–2	1–2	1–2	LMZ 841
2-place fitting set*	D 15 KP	1–2	1–2	1	LCZ 857
4-place fitting set*	D 20 KP	1–4	1–4	1	LCZ 815

* built into thermostat, can not be retrofitted.

Type	Ref. No.
Cold Trap (necessary for air-drying at $T < 0\text{ }^{\circ}\text{C}$ for connecting to a PVS-System)	LMRZ 915
Tubes for connecting thermostat/DLK	
Silicon tube 8 mm i. dia. (9 mm insulated)	LZS 001
Silicone tube 11 mm i. dia. (9 mm insulated)	LZS 007
Pump link	LZS 044

Recommended accessories:

Type	Ref. No.	Comb.
Pump link	LMZ 044	4, 5, 7, 8, 10, 11
Silicone tubing*(per m) (min. recommended: 2 m)	LZS 007	3, 6, 9, 12 ... 19

* not when using Silicone oil

Essential accessories:

Type	Ref. No.	Comb.
PT 100-92	ETP 051	15, 16, 17
Connecting cable	UK 161	18, 19

Our complete manufacturing programme

LAUDA

- ▶ Heating thermostats
- ▶ Cooling thermostats
- ▶ Accessories for Heating and Cooling thermostats
- ▶ Bath liquids
- ▶ Circulation chillers
- ▶ Interfacial instrumentation
- ▶ Viscometry instrumentation
- ▶ Heating and cooling systems

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