Visco Ball (Hoppler)

V9000

Operation Manual

PLEASE READ THIS MANUAL CAREFULLY BEFORE OPERATION

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1. Note

The company's policy can be summed up as one of continuous development and progress. We reserve the right to vary the product in minor details, to those describe in this publication.

We include all additional information that is necessary to our products and materials.

2. Important

(1) When you receive the equipment, you should verify and confirm the "delivery note".
If you find any damage or any discrepancy (anything abnormal), you should compile a damage report and advise immediately your supplier.

(2) The manufacturer's guarantee will not be valid in case that, any part or device of the equipment could be damaged because of an incorrect packing.

(3) Please read the instructions carefully

(4) All modification, elimination or lacking maintenance in any device of the equipment, transgress the directive of use 891655/CEE, and the manufacturer can assume no responsibility for any damages that could be involved.

While this instrument is in use, it may need service. In this case, you only have to phone the office, whose address is at the bottom of the page, or to your usual supplier.
It is advisable to have a regular maintenance for your equipment. We recommend that you check the viscometers once a year.

3. Safety precautions

These notes are intended to draw your attention to risks, which only you can recognize and avoid or overcome. They are intended to enhance your own safety consciousness. We have set the highest quality standards for this unit and ourselves during development and production. Every unit meets relevant safety regulations. The correct unit usage and proper handling is however solely your responsibility. The following notes must be observed:

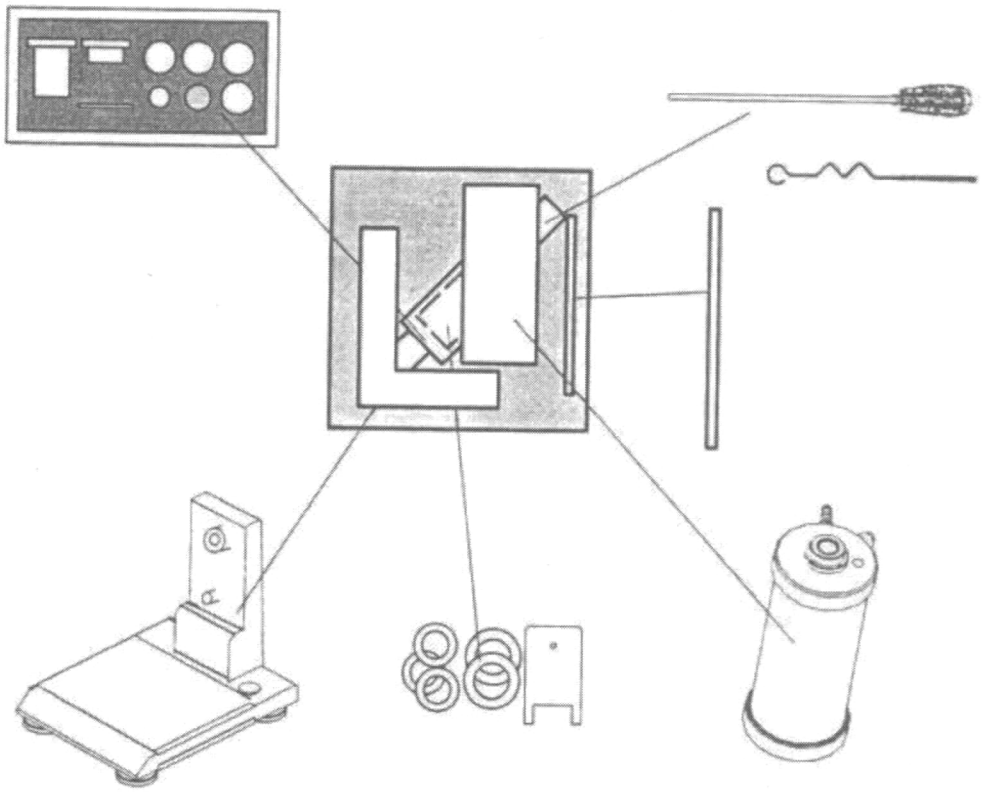
- This instruction manual must be carefully studied. It contains important information on the connection to the local mains supply, correct unit usage and safe handling.
- Check for transportation damage during unpacking. Get in contact with supplier and/or carrier for settlement of damage claims. Do not try to start up a damaged unit before the damage has been repaired or you have ascertained the effect of the damage.
- Ensure that this manual is always at hand for every unit operator. Only use this unit solely for the intended application.
- Specialist personnel must only carry out repairs, alterations or modifications. Improper repairs can cause considerable damage. The service department is at your disposal for repair work.
- Do not operate the unit with wet or oily hands.
- Do not expose the unit to spray water.
- Do not clean the unit with solvents (fire risk!) - a wet cloth soaked in household detergent is normally sufficient.
- Only use the heat transfer liquids recommended by US. Please refer to the respective EC - Safety Data Sheet.

You alone are responsible for the handling of these substances.

Our advice:

- If in doubt, consult a safety specialist.
- Read the product manufacturer's or supplier's "EC - SAFETY DATA SHEET"
- Read relevant regulations concerning dangerous materials
- Observe relevant guidelines for laboratories in your country

4. Contents of delivery



The following standard accessories are delivered together with the V9000:

Code	Description
	Falling ball viscometer, ready for testing
	Set of balls 1-6 (see chapter 10.3)
	Hollow stopper
	Stopper
	Ball tweezers
	Cleaning brush
	Cover plate
	Stopper gasket ∅ = 15.6 mm
	Thermometer gasket ∅ = 10 mm
	Socket wrench
	Instruction manual

No other material except for cleaning material (V99999 cleaning brush) is necessary at normal use.

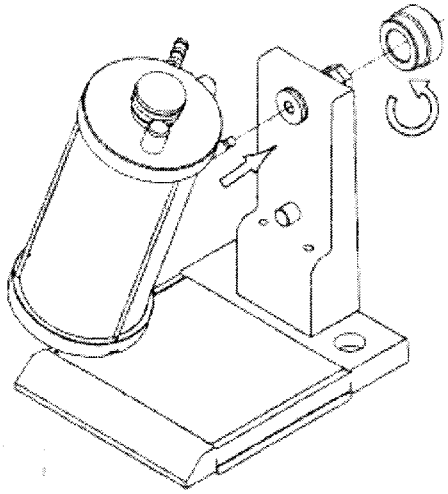
5. Falling ball viscometer

5.1. Introduction

The heart of the instrument is the Measuring tube made of glass and a ball. This tube carries two ring marks A and B, which are spaced 100 mm apart and which limit the measuring distance (ring mark C is equidistant between A and B). The measuring tube is jacketed by means of an outer glass tube, which encloses a room to be filled with a temperature-controlled liquid. The measuring tube is fastened to the stand in such a way that its axis is inclined with respect to the vertical by 10ºC during the measurement.
The measuring tube together with the jacket may be pivoted in order to turn the tube upside down again to let the ball return to the initial position before a measurement. The measuring tube is closed on both sides by two stoppers, one of which contains a capillary and a small reservoir. This stopper prevents undesirable changes of pressure in the liquid sample and has a passage for air bubbles when the temperature is being changed. The viscometer incloses all samples completely to prevent volatization and film forming. The stand may be levelled by means of its water level and the levelling screws. The easily interchangeable thermometer allows a precise temperature control.

5.2. Setting up the equipment. Assembly

Insert the measuring tube into the stand and fasten it with the knurled nut.

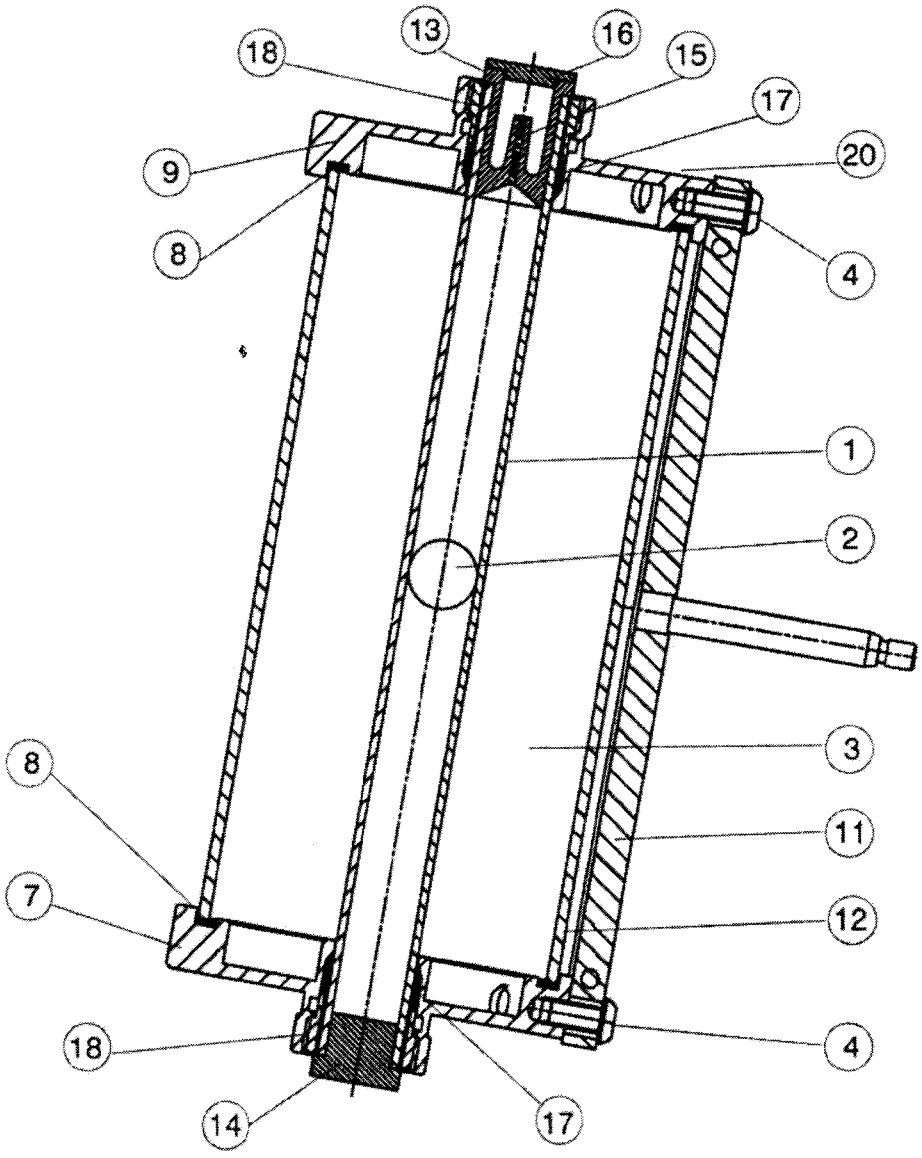


5.3. Principle of the measurement

The V9OOO Viscometer measures the viscosity of transparent Newtonian liquids. This viscosity is correlated to the time a BALL requires to fall a defined distance. The rolling and sliding movement of the ball through the sample filled into a slightly inclined cylindrical measuring tube is described by means of the fall time. The test results are given as the dynamic viscosity using the internationally standardized absolute unit of "mili Pascal·seconds" (mPa·s).

Note: 1 mPa·s = 1 cP (centiPoise)

The V9OOO Viscometer corresponds to the requirements of many international standards, i.e. ISO 12058 and the German standard DIN 53 015.



1. Falling tube
2. Ball
3. Circulation jacket
4. Screw
7. Set screw
8. Gasket
9. Cover
11. Brace
12. Jacket tube
13. Holow stopper
14. Stopper
15. Capillary
16. Closing plate
17. Gasket for falling tube
18. Threaded bush
20. Connecting rod

6. Setting up and operation

6.1. Temperature control

The V900 Viscometer may be temperature controlled in a temperature range from -20 up to +120 ºC using liquid circulators, i.e. one of the Thermovisc series from U S.

The sample should rest at least some 15 minutes in the measuring tube at the test temperature before the measurement is started.

The temperature in the jacket around the measuring tube must be maintained within a temperature tolerance of ± 0.03 ºC for test temperatures between 10 up to 80 ºC.
For test temperatures beyond these limits the tolerances may be increased to +0.05 ºC.

The tempering room (see functional elements) must be free of air bubbles.

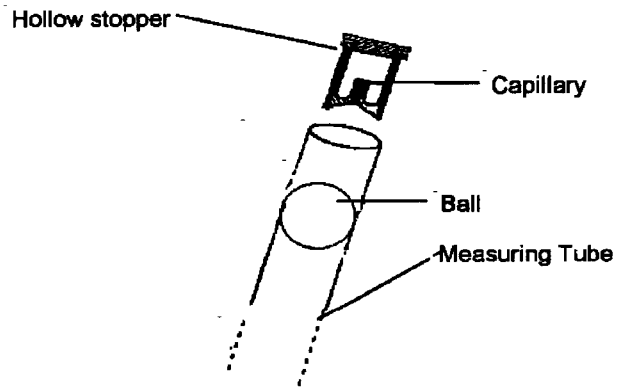
6.2. Loading the sample

All parts of the viscometer being in direct contact with the sample must be kept clean and dry.

A sample volume of approximately 45 cm^3 is poured into the measuring tube up to 20 mm below the rim of the tube. Then the ball is placed into the tube and the hollow stopper is introduced. The liquid should reach a level just beyond the capillary. The sample in the tube must be free of air bubbles.

Before the final test data are taken the ball should run through the tube up and down at least once to improve the homogeneity of the samples and its temperature uniformity.

IMPORTANT: When filling the falling tube, keep in mind that an increment of temperature will mean a dilatation into the sample. If there is not enough gap into the falling tube, when heating the viscometer, the sample dilatation can break the internal tube.



6.3. Selection of the balls.

The standard ball set contains 6 balls, which pass through the measuring tube of an inner diameter of approximately 15.94 ±0.01 mm.

Article	Ball nº	Material	Density ρ g/cm^3	Ball diameter mm.	Constant K mPa·s· cm^3/g·s (approx.)	Measuring range mPa·s
V91101	1	Borosilicate glass	2.2	15.81	0.007	0.6 ... 10
V91102	2	Borosilicate glass	2.2	15.6	0.09	7 ... 130
V91103	3	Ni-Fe	8.1	15.6	0.09	30 ... 700
V91104	4	Ni-Fe	8.1	15.2	0.7	200 ... 4800
V91105	5	Stainless steel	7.7 – 8.1	14.0	4.5	800 ... 10000
V91106	6	Stainless steel	7.7 – 8.1	11.0	33	6000 ... 75000

Additionally the following ball is deliverable:

Article	Ball nº	Material	Density ρ g/cm^3	Ball diameter mm.	Constant K mPa·s· cm^3/g·s (approx.)	Measuring range mPa·s
V91107	G	Borosilicate glass	2.2	15.91	--	gases

The measuring ranges for viscosity indicated are related to DIN 53015 and ISO 12058. Sometimes it may be necessary to use two different balls in order to cover a wider measuring range, i.e. when the function of viscosity versus temperature is

measured over a wide temperature interval; in this case, you insert two different balls at the same time into the measuring tube with the smaller bail inserted first. The reduced starting distance will not influence the test result significantly, but increases the uncertainty.

7. Measurement of the falling times

The jacket tube snaps into a defined 10° position at the bottom of the instrument.

By turning over the jacket tube, the bail is set to the measuring position. The falling time of the bail moving from the ring mark A to ring mark B is determined by using a stopwatch. The time period starts when the lower periphery of the bail touches the ring mark A, which must appear as a straight line. The falling time ends when the lower periphery of the bail touches the ring mark B, which again must appear as a straight line. If one uses the distance AC or CB to reduce very long falling times for high viscous liquids the double of the measuring time period must be taken into account.

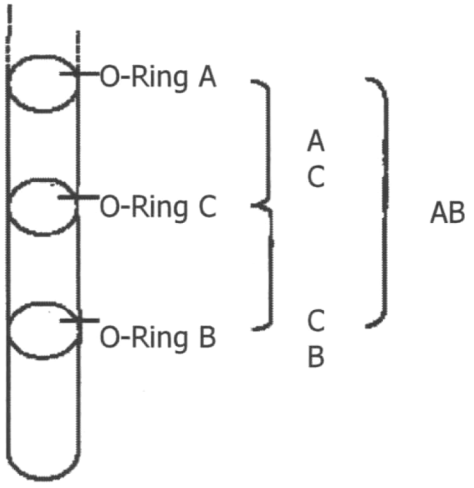
Turning the jacket tube 180° again the bail returns to its start position (it is good practice to take the mean value out of several falling time values (3 to 5)).

The falling times for the ball returning may vary from the normal value (up to 1 %). If the returning of the bail should also be used for exact measurements a new constant K must be determined.

Constant for the returning of the ball:

$$K_{return} = \frac{\text{normal falling time} \cdot \text{normal constant K}}{\text{falling time when returning}}$$

When testing dark liquids it is usually very difficult to see the lower part of the ball. In this case we advise to take the bail equator when it passes through the ring marks.



8. Evaluation of the test results

The dynamic viscosity η (in mPa·s) is calculated using the following equation:

$$\eta = K (\rho_1 - \rho_2) \cdot t$$

where:

K = ball constant mPa·s· $cm^3/g \cdot s$

ρ_1 = density of the bail in g/cm^3

ρ_2 = density of the liquid to be measured at the measuring temperature in g/cm^3

t = falling time of the ball in seconds.

The dynamic viscosity η is given in units of mPa·s (cP) and must be completed by stating the sample temperature. The dynamic viscosity η may be converted to the kinematic viscosity v by using the following equation:

$$\nu = \eta/\rho$$

ν = kinematic viscosity [$mm^2/s \rightarrow$ [1 mm^2/s = 1 cSt]]

η = dynamic viscosity [mPa·s]

ρ = density of the liquid sample [g/cm^3]

To evaluate the reliability of the results the following criteria may be used:

Reproducibility (one person, one instrument)

If one person determines two test resuits under identical test conditions, these results are supposed to be acceptable if they do not vary more than the figures stated in the table below from the average value.

Comparability (several persons, several different instruments)

If two sets of test results are reached in two different places under comparable conditions, these results are supposed to be acceptable if they do not vary more than the figures stated in the table below from the average value.

Ball nº	Reproducibility %	Comparability	
		DIN 53015	ISO 12058
1	1.0	2	2
2, 3, 4	0.5	1	2
5	0.7	1.5	1
6	1.5	3	3

Please note: Even when using balls with different diameters for Newtonian liquids identical viscosity values will be obtained.
When non-Newtonian liquids are tested varying viscosity values will result when balls of differing ball diameters are being used. Test data of non-Newtonian liquids comparing similar samples, but test results must not be given using mPa·s units.

Example

(sugar solution of 40 %)

Density of ball 2:	2.2 g/cm^3
Density of the solution:	1.18 g/cm^3
Ball constant K:	0.09 mPa·s· cm^3/g·s
Falling time:	61 s
Measuring temperature:	20.0 °C

The absolute viscosity is...

$$\eta_{20°C} = 0.09 \cdot (2.2 - 1.18) \cdot 61 = 5.6 \text{ mPa·s}$$

In most cases the densities of the test liquids are known. The evaluation may be simplified by introducing a factor which includes the densities. In our example of the sugar solution the exact factor is ...

$$(\rho_1 - \rho_2) \cdot K = 0,\ 1\ 098 \text{ (mPa·s/s)}$$

9. Viscosity determination of gases

The viscosity determination of gases has to be done with ball G that is made out of glass.

The measuring tube must be closed with rubber stoppers fitted with glass stopcocks.

→ Measuring tube, glass ball and gas must be clean and dry.

The tube is flushed several times with the gas to be tested to push out any remains of air. Then the tube filled with the gas sample is closed with the stopcocks and raised to the test temperature.

The calculation of the gas viscosity is based on the comparison with the viscosity of air at 20 °C ($\eta = 1815 \cdot 10^{-5}$ mPa·s):

$\eta_{gas} = (FG / FA) \cdot 1815 \cdot 10^{-5}$ mPa·s

where:

η_{gas} = viscosity of the gas at the temperature T

FG = falling time of the ball in the gas at the temperature T

FA = falling time of the ball in air at a temperature of +20 °C

Viscosity of the air at a temperature of +20 °C = $1815 \cdot 10^{-5}$ mPa·s

10. Cleaning the measuring tube

Usually the tube is cleaned by rinsing it with a suitable solvent.

High viscous liquids (glue and heavy oils, etc.) have to be removed with the cleaning piston, which is optional with the instrument. Push this piston slowly through the tube. After this, there will be only a thin film of the liquid left on the walls of the tube that then can be removed with a solvent.

Especially when measuring with balls 1 and G it is very important, that the tube and the bail are clean and dry.