BGD **611**

Falling Rod Viscometer

INSTRUCTION MANUAL

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ABOUT US

Biuged Laboratory Instruments（Guangzhou）Co. Ltd. is one of leading professional manufacturers of instruments used in the paint, ink and coatings industry in China.

Originally formed in 1963, we have grown to an internationally recognized business with a worldwide customer base which includes the worlds leading paint and coatings manufactures and users. Till now, we have established more than 50 agents or offices in all over the world. We have a team of dedication, high level education, cooperation and strong creativity. Our instruments are of both high quality and high ratio of performance to price so that products are salable to world- wide market.

Our RR&D department continually investigates new product design ideas, in conjunction with the major standards committees, in order to supply up to date instrumentation for the Quality Control of coatings. We always apply the advanced contemporary techniques and experience to our new products.

Our manufacturing department ensures that all our products are built to the highest quality, every instrument undergoing rigorous calibration and testing before it leaves our factory. We also can supply the third side calibration certificate when customer need.

Our service department, which has expanded to meet the increasing demand for maintenance and calibration both in-house and in the field, offers a full range of services

'Quality first and user uppermost' are one of our claims. Our Instruments strive for best in quality and after-sale service. Satisfying your needs are our wishes.

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1.0 Introduction:

BGD 611 Falling Rod Viscometer is an instrument applicable to determine the rheological properties (apparent viscosity, pseudo yield value, shortness, etc) of Non-Newtonian liquids (viscosity increases with shear rate). BGD 611 Falling Rod Viscometer designed and produced by our company is in accordance with the specification of ISO12644: 1996(E)《Graphic technology--Determination of rheological properties of paste inks and vehicles by the Falling Rod Viscometer》. Its principle: measuring fall times by loading the rod with different load weights pass the gap which is filled with the test fluid. By applying linear regression methods & by means of suitable flow model (Caisson model, Bingham model or Power Law model) to obtain apparent viscosity、 yield value、 shortness ratio of sample.

2.0 Main Technical Parameters:

- Input voltage: 220V 50Hz
- Range of apparent viscosity: 2-200Pa.s
- Dimensions of the falling rod: Φl2x300mm
- Weight of the falling rod: 132g
- Sets of load weights (total 4075g): 25-50-100-200-200-500-1000-1000-1000g
- Overall dimensions: 140mm×140mm×300mm (length by width by height)
- Weight(including instrument、 weight box、 controller): 18kg

3.0 Preparation before operation:

3.1 Take the instrument out from the box, level it.

3.2 Insert signal connecting wire plug, insert temperature sensor into diagonal hole of guide bush of Falling Rod Viscometer.

3.3 Separately connect two lead out latex pipes from thermostatic bath (ordering separately) to thermostatic (water) jacket.

3.4 Turn on power, switch on the power of thermostatic bath and electronic controlling box, temperature indicator display current temperature of guide bush of falling rod Viscometer, timing indicator should display 0.00 sec. (Note: specific operation of thermostatic bath refers to instruction manual).

3.5 Testing Environment: 25℃±2℃. When the temperature of guide bush of Falling Rod Viscometer reaches 25℃±2℃, the test shall be carried out.

3.6 During operation, a naked Hand should be avoided to touch guide bush & falling rod so as to cause man-made warming-up. Guide bush & falling rod should be touched by hand with glove.

4.0 Test procedure:

4.1 Prior to use, the test sample (about 5g) shall be kneaded by a spatula and equilibrated to test temperature. The sample shall be homogeneous and not contain any coarse particles. An amount of the test sample sufficient to coat the rod and aperture is applied to the lower part of the rod.

4.2 The bottom of the rod is inserted into the aperture of guide bush and slightly fall on the turntable, the sample is distributed uniformly around the gap, the gap is filled with the test fluid which is sheared when the rod falls by using fingertip; lift the bottom of the rod 20mm, then fall on the turntable.

4.3 Load weights to be loaded on top of the rod, remove a turntable to let falling rod fall, the rod and the aperture are wetted by the liquid; Make sure that photoswitch & temperature sensor are working

normally (temperature indicator display starting temperature when starting falling, time indicator starts to display seconds; temperature indicator display finishing temperature when finishing falling, time indicator display actual fall time; temperature resume to display actual temperature of guide bush after pulling up the rod, time automatically clear.

4.4 Avoid any scoring operation for the rod, the metal spatula should not be allowed operation for the rod; Don't do falling operation under the condition of no test sample. After finishing falling, the rod is lightly pulled up and rested on the support. After each run, the rod is scraped with the spatula and the liquid which was scraped off is reapplied on the lower part of the rod & the aperture of guide bush.

4.5 The proper sets of load weights is selected according to the expected results. The fall time with the heaviest load weight should normally be in the range from 4s to 10s (ASTM D4040-05 recommend 1-2s. Series of load weights are combined to sets. Sets of load weights with the following masses should be used: (Unit: g)

A: 5000 4000 3000 2000 1000

B: 3000 2000 1500 500

C: 1500 1000 800 500

D: 800 600 400 200

E: 400 300 200 100

F: 200 100 50 0

4.6 The sample is tested with the heaviest load weight at the beginning of the tests, load weighs in descending order. Fall time during the test with the heaviest load weight varies less than 0.5s, the sample is tested with the selected series of load weights in descending order. The fall time shall not exceed 60s. After each run, the rod is scraped with the spatula and the liquid which was scraped off is reapplied on the lower part of the rod. During the test, additional liquid shall not be added. The sample is tested with each load weight for three times. By loading the rod with different load weights record the fall time every time (correct to 0.01s), and temperature of guide bush during measurement (correct to 0.1 ℃).

4.7 Operation shall be done quickly and can't be interrupted, the whole operation shall be finished within 5-10 minutes. Many printing ink and vehicles have strong volatile solvent, only if strictly control actual exposition time, otherwise volatile loss cause large deviation of test result during operation. If found several continuous falling with the same load weight, fall time could be longer, it indicates that obvious volatile loss exists.

4.8 Viscosity is strongly temperature dependent, therefore the temperature shall be controlled and monitored. Principally, if the test temperature varies from reference temperature (25℃) by more than 0.2℃ before the runs, the thermostatic equipment shall be reset, if the temperature during the test varies more than 1℃, the test shall be repeated.

4.9 After the test, the instrument shall be cleaned immediately with a lint-free wiper and a suitable solvent, especially the rod & guide bush.

5.0 Data process

5.1 For the purpose of ISO standard, device factor ct, 13is defined as the following ratio.

$$\alpha=\frac{L}{s} \qquad \text{.....(1)}$$

$$\beta=\frac{g}{2p\mathrm{rl}} \qquad \text{.....(2)}$$

Where: L-is the measuring distance (m)

s-is the thickness of the ink in the nip determined by the difference between radii of the aperture and of the rod (m).

g-is the gravitational acceleration (9.80665m/s^2)

π- is the circumference ratio (3.1416)

r- is the radius of the rod (m)

l- is the length of the aperture (m)

5.2 Shear stress & shear rate

$$g = \frac{a}{t} \quad \text{.....(3)}$$

$$s = b \cdot m \text{.....(4)}$$

Where: γ -is the shear rate (s^{-1})

t- is the fall time (s)

σ -is the shear stress (Pa)

m- is the total mass of the rod and the weight load (kg)

5.3 Calculate viscosity

$$h = \frac{s}{g} \quad \text{.....(5)}$$

Where: η-viscosity (Pa.s)

5.4 For Newtonian liquid, viscosity η is constant, calculating average value as viscosity of tested sample. But Falling Rod Viscometer is used for testing viscosity of Non-Newtonian liquid of tested sample, the viscosity is changed according to different shear rate. Apparent viscosity (also called Laray viscosity) is for Non-Newtonian liquid of tested sample, ratio of the shear stress o to the shear rate γ, α τ α defined shear rate when applying describe rheological behavior of printing ink, typically to 2500s^{-1}.

5.5 Apparent viscosity at 2500 s^{-1}, ratio of the shear stress σ to the shear rate γ ISO recommends three flow models: Casson model、 Bingham model and Power Law model, these three models mentioned are suitable for describing the rheological behavior of inks. The selection of a specific model should be determined by practical experience. The values of each of the rheological quantities strongly depend on the selection of the flow model. There are no equations to transform the results from one model to any other.

5.6 Although ISO standard recommends three flow models, Falling Rod Viscometer generally adopts Power Law model for calculation (ASTM D4040-05 《Determination of rheological properties of paste inks and vehicles by the Falling Rod Viscometer》 only recommends Power Law model for calculation. Other flow model's calculation refers to ISO standard.

5.7 ISO standard defines Power Law model:

$$s = kg^N \text{.....(6)}$$

Where: k-constants relates to fluid viscosity.

N--describes constants of non-Newtonian characteristic gradation.

5.8 For Newtonian fluid, N=1; N<l's non-Newtonian shear thinning liquids (pseudo plastic fluid), most printing ink shear thinning liquids; N>l's non-Newtonian shear thickening liquids (dilatants fluid), For printing ink and vehicles, usually it doesn't exist such situation. If N>1-1.05, please check data or the test shall be repeated.

6.0 Data Process:

6.1 If the test temperature varies from reference temperature (25℃±2℃) during testing, the following equation is used to correct the fall time:

$$t = t_{measured}[1 + d_t(T_{measured} - 25)]$$

Where: t- fall time after correcting (s)

$t_{measured}$- fall time during test. (s, is defined to be average for same weight)

d_t - temperature correction factor, for printing ink, it recommends adopting 0.1

$T_{measured}$ - temperature during test (℃, is defined to be average for same weight)

6.2 Fall mass (kg)is the total weight of the rod and the weight loads. Equation (3) and (4) are used together with t and m-per group (the device factor α &βhave been given) to calculate σ and γ.

6.3 For Power Law model, a double logarithmic plot of shear stress versus shear rate is used to obtain the following linear relation.

Log σ =logk+N log γ

Using step 2 calculate σ and γ each group, values of logk and Ion N are obtained from linear regression using above equation, then calculate k and N.

6.4 Linear regression correlation coefficient should be calculated as a measure of the repetability of the test. For correlation coefficient values of 0.999 or better the results are reliable. In case of lower correlations the test shall be repeated.

6.5 Test results are obtained with the following equation

Apparent viscosity (Laray viscosity) = $K \cdot 2.5^{N-1}$

Pseudo yield stress (yield stress)=$K.2.5^N$

Shortness ratio(Shortness) =Ratio of pseudo yield stress to the apparent viscosity.

6.6 If a certain set of rod and aperture ring shows viscosity variations of >20% from the specifications of the standard viscosity oil it shall be discarded. Smaller differences are compensated by using a correction factor6. The following equation is used to calculate apparent viscosity:

Apparent viscosity= $d \cdot k \cdot 2500^{N-1}$

6.7 The above shows brief introduction about data Process, actual calculation adopts software (software is provided by an attached disc).

7.0 Note:

7.1 The rod, guide bush and photo switch, controlling box must be matching operation according to number, they should not be interlace operation, otherwise device factors α、β will be invalid.

7.2 The rod and guide bush are high accuracy parts, their accuracy directly influence data, so tested sample is not allowed to contain any coarse particles, the spatula used for scrapping ink must be made of plastic or other soft material so as to avoid scoring.

7.3 Device factors α、β and a correction factor δ are measured by our company's examiner in our factory, attached with a disc.

7.4 During measurement, a rod and a guide bush wear continually, device factors and correction factor also vary a little bit, so the viscometer should be sent back to our company for checking & correcting every year.

7.5 Falling Rod Viscometer is used for chemical material process, safety and health protective step

must be set up in accordance with all local codes and ordinances Before using this machine, safety problem associated with chemical material must be established by user, not belonging to explanation of this Instruction Manual.

7.6 It is our goal to bring increased performance and greater value to these established products as quick as possible. Our company reserves the right to make changes without notice at any time.

8.0 Packing List

- Principal Machine ×1
- Controlling Box ×1
- Sets of load weights ×1
- Spatula ×1
- Photoswitch & Temperature Sensor ×1
- Thermostatic (water) Jacket ×1
- Latex Pipes 6×9 2×1.5M
- Power-Line Connection ×1
- Instruction ×1
- Attached Disc (Operation video & software) ×2

10.0 OTHERS

For further information contact Biuged, your local supplier, or visit our website at **www.biuged.com**