Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

Working Group 3.32 “Properties of Liquids“

Non-Newtonian test liquids of viscosity

PTB supplies two non-Newtonian test liquids with good long-term stability. Liquid NNTF1, a solution of a polystyrene-polyisoprene copolymer in a low-viscous hydrocarbon oil reveals a yield point. Liquid NNTF2, an aqueous solution of a copolymer of diallyl-dimethylammonium chloride und acryl amide reveals pseudoplastic behaviour..

These test liquids are intended for controlling a rotational viscometer, especially for the experimentally control of the uncertainty budget of the viscometer.

Calibrations of rotational viscometers should be performed according to DIN 53019 Part 2 with Newtonian reference liquids.

Further information and guide values are given on the following pages.

Characterisation of the non-Newtonian test liquid NNTF1

The measurements were made by means of rotational viscometers being calibrated according to DIN 53019-2. All specifications refer to the stationary state of equilibrium.

In the shear-rate range of $1\ s^{-1} \le \dot{\gamma} \le 10\ s^{-1}$ the flow curve is described using Bingham's flow law :

$$\tau = 10.7\ Pa + 0.053\ Pa{\cdot}s\ \dot{\gamma}$$

The measurement uncertainty (k = 2) is 2.3 Pa for the yielding point determined by extrapolation to $\dot{\gamma} = 0\ s^{-1}$.

In the shear-range of $10\ s^{-1} \le \dot{\gamma} \le 600\ s^{-1}$, the shear stress τ transferred in the non-Newtonian test liquid of viscosity at 20℃ follows a flow law of Ostwald-de-Waele type described by the numerical-value equation (τ in Pa, $\dot{\gamma}$ in s^{-1}) (see Fig. 1):

$$\tau = K \cdot \dot{\gamma}^{n} \text{ with K = 3.6419 and n = 0.4882.}$$

The relative measurement uncertainties (k = 2) for this flow curve $\tau(\dot{\gamma})$ as well as for the description of the flow law by means of inverted function $\dot{\gamma}(\tau)$ are stated in the tables 1a and 1b.

The time starting with insertion of the sample until the end of the measurement should not exceed 20 min, as volatile components can vaporise from the sample. The sample is a solution of six volume percent of a polystyrene-polyisoprene copolymer in a low-viscous hydrocarbon oil. The temperature-viscosity coefficient at 20℃ is 0.01 K^{-1} according to DIN 53017:1993.

The bottle must be kept at temperatures up to 30℃ at the most and in the dark. The bottle has to be opened only for sampling and has to be be closed immediately afterwards. This calibration certificate is valid up to six months following the calibration date of the sample, provided that the bottle will not have been opened until then.

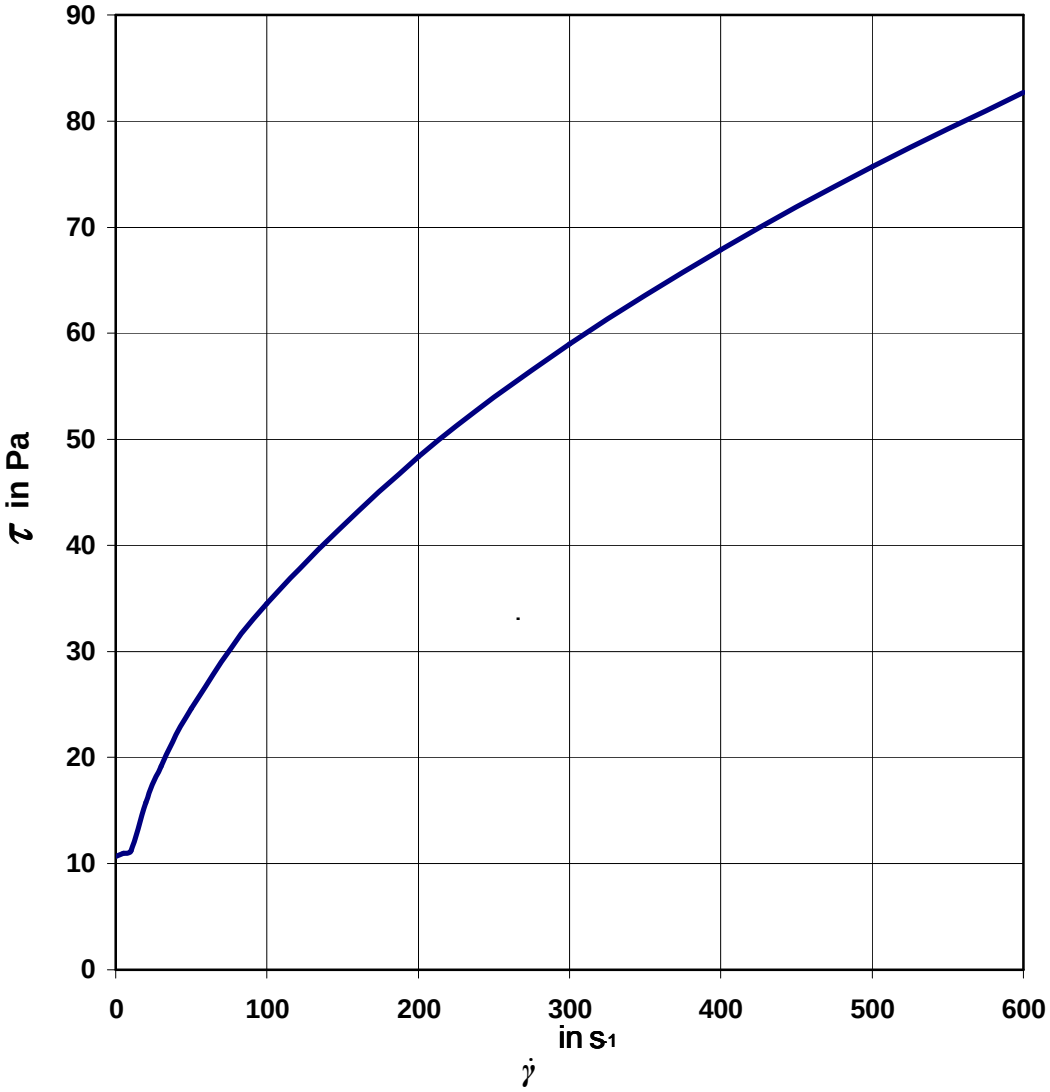

Fig. 1: Typical flow curve of NNTF1

Table 1a: $\tau(\dot{\gamma})$ for NNTF1

Shear rate $\dot{\gamma}$ [1/s]	Shear stress $\tau(\dot{\gamma})$ [Pa]	Relative measurement uncertainty (k = 2) of the flow curve $\tau(\dot{\gamma})$ [%]
20	15.72	4.5
30	19.16	4.0
50	24.59	3.7
100	34.49	3.5
200	48.38	3.5
300	58.97	3.5
400	67.87	3.5
500	75.68	3.4
600	82.72	3.4

Table 1b: $\dot{\gamma}(\tau)$ for NNTF1

Shear stress τ [Pa]	Shear rate $\dot{\gamma}(\tau)$ [1/s]	Relative measurement uncertainty (k = 2) of the flow curve $\dot{\gamma}(\tau)$ [%]
16	20.73	9.2
20	32.75	8.2
30	75.14	7.3
40	135.45	7.1
50	213.93	7.1
60	310.79	7.1
70	426.19	7.1
80	560.26	7.1
82	589.32	7.0

Result measured for the non-Newtonian test liquid NNTF2

The tests were made by means of rotational viscometers calibrated according to DIN 53019-2. All indications refer to the stationary state of equilibrium.

In the shear-rate range 0 $s^{-1} \leq \dot{\gamma} \leq$ 600 s^{-1}, the shear stress τ transferred in the non-Newtonian test liquid of viscosity at 20℃ follows a flow law of Ostwald-de-Waele type described by the numerical-value equation (τ in Pa, $\dot{\gamma}$ in s^{-1}) (see Fig. 2):

$$\tau = K \cdot \dot{\gamma}^n \text{, with } K = 16.725 \text{ and } n = 0.3392.$$

The relative measurement uncertainties (k = 2) for flow curve $\tau(\dot{\gamma})$ as well as for the inverted function $\dot{\gamma}(\tau)$ are given in the tables 2a and 2b.

The time starting with insertion of the sample to the end of the measurement should not exceed 15 min as water can vaporise from the sample. If possible, a solvent trap should be used. The sample consists of an 8% aqueous solution of a copolymer of diallyl-dimethylammonium chloride und acryl amide. At 20℃, the temperature-viscosity coefficient according to DIN 53017:1993 is 0.005 K^{-1}.

The bottle must be kept at 25℃ at the most and in the dark. The bottle has to be opened only for sampling and has to be be closed immediately afterwards.

This calibration certificate is valid up to 6 months after calibration date of the sample, provided that the bottle will not have been opened until then.

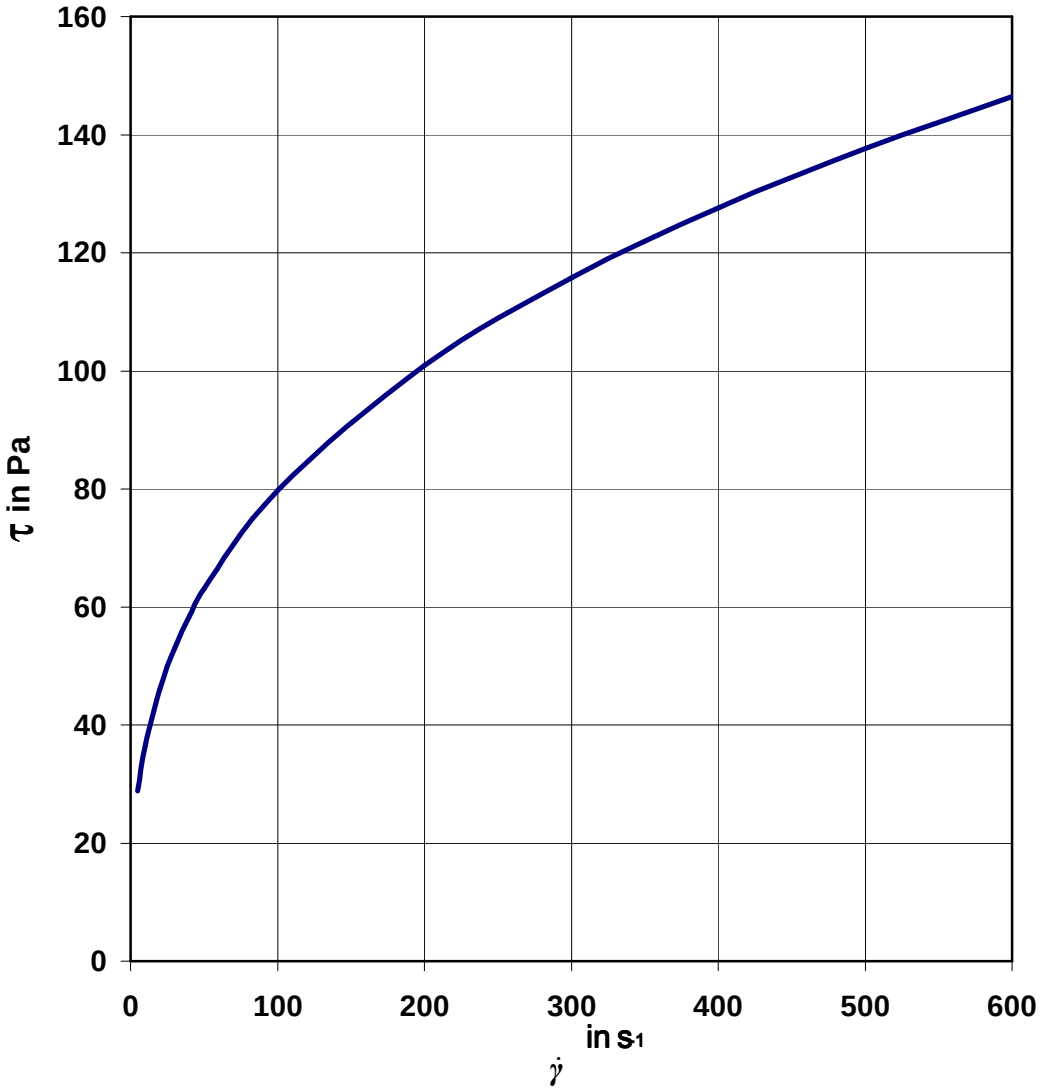

Fig. 2 : Typical flow curve of NNTF2

Table 2a: $\tau(\dot{\gamma})$ for NNTF2

Shear rate $\dot{\gamma}$ [1/s]	Shear stress $\tau(\dot{\gamma})$ [Pa]	Relative measurement uncertainty (k = 2) of the flow curve $\tau(\dot{\gamma})$ [%]
5	28.87	5.2
10	36.52	4.8
20	46.20	4.3
30	53.02	4.0
40	58.45	3.9
50	63.05	3.8
100	79.76	3.4
200	100.90	3.4
300	115.77	3.4
400	127.64	3.4
500	137.68	3.4
600	146.46	3.4

Table 2b: $\dot{\gamma}(\tau)$ for NNTF2

Shear stress τ [Pa]	Shear rate $\dot{\gamma}(\tau)$ [1/s]	Relative Measurement uncertainty (k = 2) of the flow curve $\dot{\gamma}(\tau)$ [%]
30	5.599	15
40	13.075	14
50	25.243	12
60	43.209	11
70	68.067	11
80	100.90	10
90	142.79	10
100	194.81	10
110	258.01	10
120	333.46	10
130	422.20	10
140	525.30	10

Inquiries can be made to:

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The samples are generally delivered within four weeks after receipt of order.

The costs are charged according to the Regulations governing charges for services rendered by PTB and calculated according to the average work done, which is necessary for the determination of the density, dissemination and supply of the test liquids depending on the quantity delivered. VAT is not being charged.

Each sample (100 ml) costs €350. A transport flat rate is charged, which is €10 for the first liquid when dispatched within Germany; €25 within the EU; otherwise €40; for each additional liquid the flat rate increases by €5. If requested by the customer, the delivery can be effected carriage forward with the parcel service suggested by the customer.