The Du Noüy Ring (DHR-3, DHR-2, AR-G2 Only)

The Du Noüy ring measuring system is mainly used to determine the linear viscoelastic properties of the interface between a liquid and air. It consists of a thin wire ring and a Duran glass dish (Figure 1.1). The ring is constructed from a platinum / iridium (Pt/Ir) alloy for chemical inertness, ease of cleaning, and wettability. It is important that the ring and dish aligned concentrically, and a locating ring is provided that fits over the Peltier plate to ensure this. Two dishes are available; the outer diameter of the standard dish is 70 mm and the outer diameter of the small dish is 50 mm.

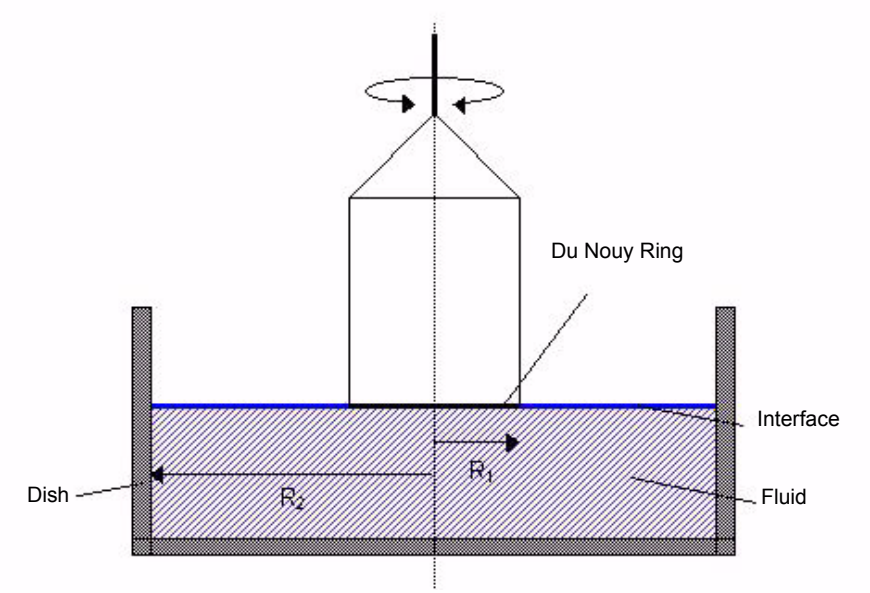


Figure 1.1
Du Noüy Ring Measuring System Schematic
R_1 is the ring radius, R_2 is the dish inner radius.

Du Noüy Ring Dimensions

Dish (standard):	Depth	30 mm (approx)
	Outer diameter	70 mm
	Inner diameter	66 mm (approx)
	Material	Duran glass (Schott AG)
Dish (small)	Depth	30 mm (approx)
	Outer diameter	50 mm
	Inner diameter	46 mm (approx)
	Material	Duran glass (Schott AG)
Geometry:	Ring diameter	10 mm
	Inertia	0.70 μNm s^2 (approx), including holder
	Material	Platinum / iridium (Pt/Ir) alloy
Temperature control:	Peltier plate	

Setting Up the Geometry Details in TRIOS Software

The Du Noüy ring can be treated as an interfacial analogue of the concentric cylinder system, and analogous factors can be used. The interfacial measuring system factors are:

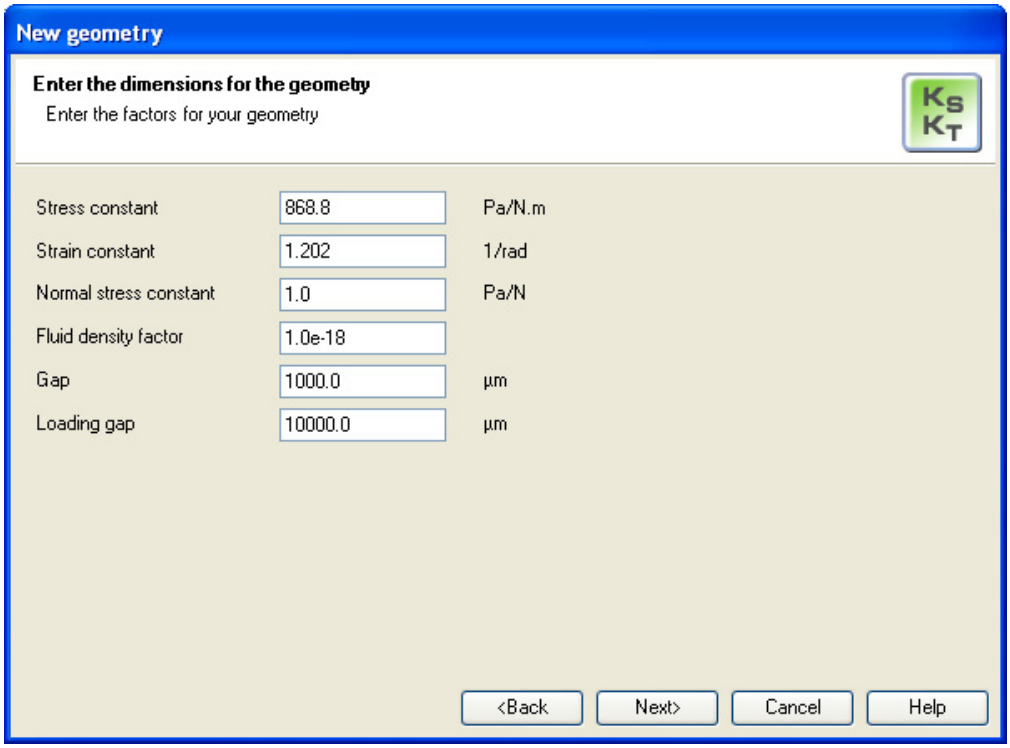
$$F_\gamma = \frac{R_2^2 + R_1^2}{R_2^2 - R_1^2} \qquad F_\sigma = \frac{1}{4\pi}\left(\frac{R_2^2 + R_1^2}{R_2^2 R_1^2}\right) \qquad F_m = \frac{1}{4\pi}\left(\frac{R_2^2 - R_1^2}{R_2^2 R_1^2}\right)$$

where R1 is the radius of the Du Noüy ring, and R2 is the inner radius of the cup or dish. The factors for the Du Noüy ring are given in the table below.

Dish inner diameter	Ring diameter	S.I. units		c.g.s. units	
		F	F_σ	$F\ \dot{\gamma}$	F_σ
(mm)	(mm)	$-\dot{\gamma}$	m^{-2}	--	cm^{-2}
66	20	1.202	868.8	1.202	0.08688
46	20	1.466	946.2	1.466	0.09462

Set up the Du Noüy ring as a Special Geometry in TRIOS Software using manual factors:

1. From the **Geometry** ribbon, click **New**, then click **Next>**.
2. Scroll to and select **Special Geometry,** then click **Next>**.
3. Using the above table for reference, enter the measuring system factors, as shown below.



4. Click **Next>** to continue with the new geometry setup. Fill in the available fields as appropriate for your application to complete the New Geometry Setup.

Setting Up the Du Noüy Ring

Follow the instructions in this section to set up the ring.

CAUTION: Handle the Du Noüy ring with care: it is delicate and can easily be deformed or broken.

Zeroing the Gap

Follow these steps to zero the gap:

CAUTION: To avoid damaging the Du Noüy ring, zeroing the gap should only be done with the gap zero tool, not with the ring.

1. Ensure that the Peltier plate is fitted to the instrument.
2. Insert the zero gap tool into the geometry holder, ensuring that the tool is fully seated in the centering hole, and fix it in place by turning the collet.
3. Raise the head of the instrument and attach the geometry holder to the draw rod (see Figure 1.2).
4. Zero the gap in the usual way.
5. Remove the holder from the spindle and the tool from the holder.

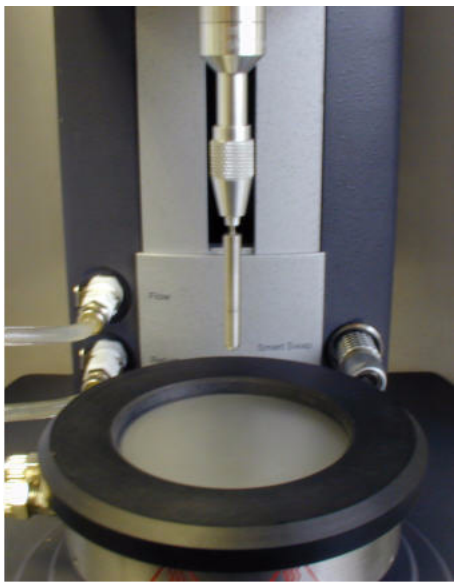


Figure 1.2
Zero Gap Tool in the AR-G2 Geometry Holder

Mounting the Ring on the Spindle

Follow these instructions to mount the ring:

1. Raise theinstrument head.
2. Attach the geometry holder to the draw rod, then insert the Du Noüy ring into the holder, ensuring that it is fully seated in the centering hole. Turn the collet to secure. This is best done if the rheometer spindle is locked by pressing the button on the front panel, or you may find it easier to install the ring into the holder before attaching the holder to the draw rod. Tighten the collet finger tight, do not overtighten. (See Figure 1.3 on the next page).
3 Place the sample dish locating ring on the Peltier plate. Use the insert if the 50-mm diameter dish is used.
4. Proceed to the next section to perform the mapping function.

Mapping

After the ring is mounted, perfrom the mapping function as follows:

1. Lower the instrument head until the ring is about 40-mm above the Peltier plate.

2. Use the oscillatory mapping function described in theTRIOS Software Help System. Make sure that you do not touch the instrument head or the Du Noüy ring after the mapping.

3. Load the sample as described in the next section.

Loading the Sample & Locating the Interface

Follow the instructions below:

1. Load the sample into the dish. The depth of the sample is not critical, but about 15 mm is reasonable.

2. Place the dish on the Peltier plate within the locating ring.

3. Lower the head until the ring is in the plane of the sample surface. This may be done by entering the approximate height of the sample surface above the Peltier plate, as the **Gap Required Value** then click **Send**. Fine adjustment can be made manually. The rate of head movement for manual control is set in TRIOS Software under gap control **Other Velocity**.

4. Ensure that the ring is fully wetted by bringing it completely through the surface the approach the surface from below (See Figure 1.3)

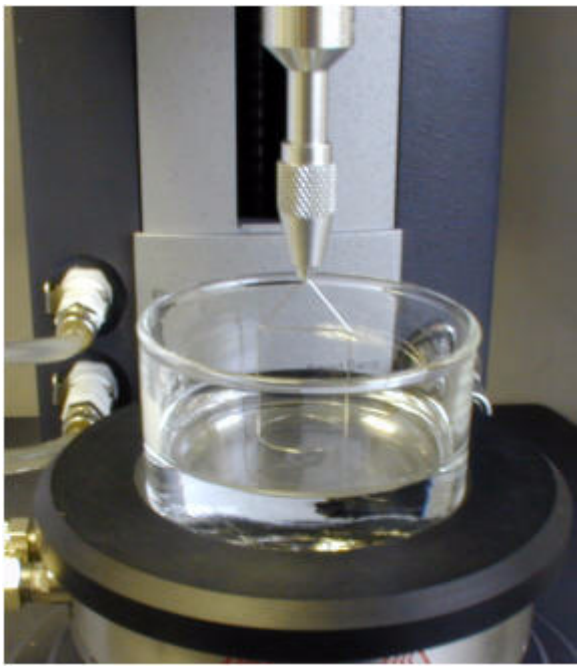


Figure 1.3
Du Noüy Ring at the Liquid Surface

5. Gently fit the draft shield in place, ensuring that the shield does not touch the Du Noüy ring or instrument head while fitting.

6. Begin the experiment.

Calculation of Interfacial Linear Viscoelastic Properties

The properties of the interface as measured using the TA Instruments Du Noüy measuring system are absolute, *i.e.*, the contribution from bulk liquid is not subtracted. If the excess interfacial moduli are required, the properties of the bulk fluid / air interface need to be accounted for. This is not normally necessary if water is the bulk liquid, since the moduli of the water / air interface are very low.

NOTE: The units for the interfacial moduli are N m^{-1} for S.I. units, and dyne cm^{-1} for cgs units, not as reported by TRIOS Software. The units for the magnitude of the interfacial complex modulus, $|G^*_{interfacial}(\omega)|$ are N m^{-1} for S.I. units, and dyne cm^{-1} for cgs units, and the units of the interfacial shear stress are are N m^{-1} for S.I. units, and dyne cm^{-1} for cgs units. The phase angle, δ, is dimensionless.

Cleaning

The biggest source of error when making surface rheological measurements is contamination of the ring or dish. Both the ring and dish should be thoroughly cleaned before and after use.

Cleaning the Ring

To clean the ring:

1. Remove the ring from the rheometer.
2. Rinse or soak the ring in an appropriate solvent.
3. Use a micro-jet gas burner to burn off any additional residue. Position the flame on the ring until it glows red. Every part of the ring that will be in contact with the sample should be treated in this way.

WARNING: Do not attempt to flame the Du Noüy ring while it is mounted on the rheometer. This could cause serious damage and may be dangerous. Take care when flaming the Du Noüy ring. It can be held by the holder, but do not grasp it directly. Ensure that no flammable materials are nearby. Do not touch the ring or place it in contact with flammable materials until it has cooled down.

Cleaning the Sample Dish

Clean the sample dish using a proprietary cleaning agent. Then rinse it thoroughly with distilled water. You can also safely heat the dish to 500°C in an oven.