1-1.1 Torsion Rectangular, V1 Design (ARES-TRECT) *(also for use with RAA/RDA-2*

Strain Constant	Stress Constant
$K_\gamma = \frac{T}{L}\left(1-\left(0.378\left(\frac{T}{W}\right)^2\right)\right)$	$K_\tau = 1000\left(\frac{3+\left(1.8\left(\frac{T}{W}\right)\right)}{WT^2}\right) G_c$

Variables

G_c = Gravitational constant
= 980.7(cgs) or 98.07(SI)

T = Thickness of sample (mm)

W = Width of sample (mm)

L = Length of sample (mm)

Options

Clamps to accommodate thicknesses up to 6.35 mm

Environmental Systems

Ambient
Oven

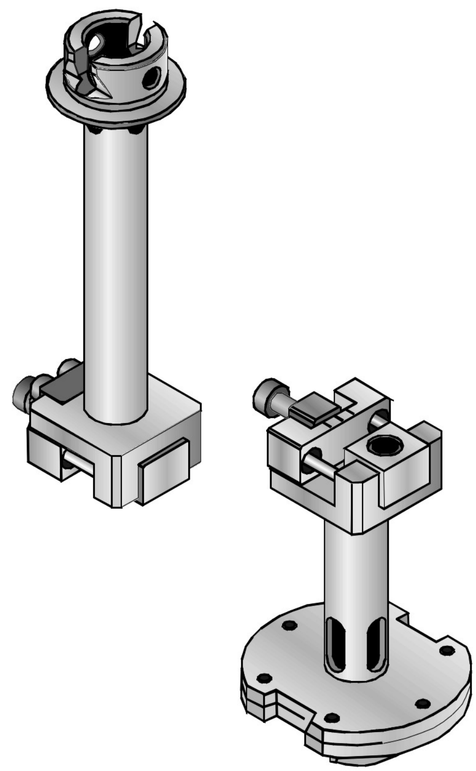

Figure 1 New Design Torsion Rectangular Fixture (ARES-TRECT)

General Information

Since early 1970s, Rheometrics used a type of torsion rectangular fixtures on various Rheometrics instruments. In late 1999/early 2000, the original design torsion tools were redesigned for ARES Rheometers. These new design Torsion Rectangular (ARES-TRECT) fixture is also downwards compatible with your RAA/RDA-2 (Rheometrics Rheosource Series Rheometers). Since 2003, Patel Scientific Corporation supports all Rheometrics ARES and RAA/RDA-2 instruments.

The re-designed Torsion Rectangular fixture is used for testing solid materials with high modulus, including thermosets, thermoplastics and elastomers. The sample is held in tension between the upper and lower tool. Three setting anvils (Figure) are provided to accommodate samples of varying thickness. Each setting anvil is designed to provide clamping for two different sample thickness ranges, which are listed below.

What is included with the New Design Torsion Fixtures for use with RAA/RDA-2?

The following items are included with the new design fixture for use with the RAA/RDA-2:

- A New Design Lower (Shorter) Torsion Fixture Assembly (with spring loaded baffle assembly).
- A New Design Upper (Longer) Torsion Fixture Assembly (with spring loaded baffle assembly).
- Three Sets (total six pieces) of Anvil (removable blocks) which can be changed to accommodate different size thickness of samples. The anvil sizes are listed in this procedure (next page).
- One Set of Metrix HEX wrenches.
- One Adjustable Precision Torque Wrench (range 20 to 200 cNm) and a 3mm Hex Bit.
- One Steel Sample (Part Number 400-02589) which is used for checking Phase Angle in the Rheometers equipped with 2KSTD or 2KFRTN1 or 10KSTD Transducers. (Note: For software data entry purpose, the Length of the sample is approximately 45mm, Width = 12.7mm and Thickness = 0.762mm)
- One specially modified Thumb Nut for use with RAA/RDA-2 instruments. (The original thumb nut on the tool mounting hardware mechanism of the motor is too big to work with this new Lower Torsion Fixture. So the user is expected to remove the original Thumb Nut from the RAA/RDA-2 Motor assembly tool mounting hardware mechanism and replace it with this new thumb nut). **NOTE:** This special Thumb Nut is **NOT** provided for use with ARES Rheometer.
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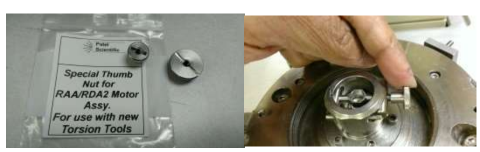
Figure 2, New Design (V1) ARES Torsion Fixture in box



Figures 3 & 4 (using special short Thumb Nut for RAA/RDA-2*)

***Thumb Nut is Only provided for RDA-2. It is NOT provided for ARES**

Sample Dimensions

To prepare samples that fit within the physical constraints of the fixture, use the following guidelines:

- Maximum Sample Width: 12.7 millimeters
- Typical Sample Length: 45 millimeters for Ambient use without Oven *(less if Oven is used)*
- Sample Thickness depends on the size of the setting anvil used:

Setting Anvil	Nominal Thickness Stamped on Face	Actual Sample Thickness Clamping Range
1	0.3 mm	Up to 0.6 mm
	*1.0 mm**	0.6 to 1.5 mm
2	2.0 mm	1.5 to 2.5 mm
	3.0 mm	2.5 to 3.5 mm
3	4.0 mm	3.5 to 5.0 mm
	6.0 mm	5.0 to 6.5 mm

***For Phase Angle Calibration using supplied Steel Sample use 1.0mm thickness* anvil.**

Clamping Torque

Always use the correct size setting anvil for the sample thickness. If the sample does not fit properly in the tool, erroneous data may result. Adjusting the sliding clamps to the proper tightness is imperative. A precision torque wrench is included with this tool. For each material, some experimentation may be required to find the best clamp torque value to obtain good results. Under tightening, or for softer materials, over-tightening the clamps will result in erratic data. Once a good torque value is obtained for a specific sample (material and thickness), all subsequent samples should be tightened to the same value. Also, both clamps should always be tightened to the same torque value.

**For Phase Angle Calibration using supplied Steel Sample use 60 cNm setting on the adjustable Torque Wrench*

> **NOTE**
> **Loading soft/rubbery samples or samples that do not properly fit the clamps can result in inaccurate data.**

Operating Ranges

Operating range is defined as the region bounded by the maximum and minimum complex modulus G^* that can be measured by each transducer type using the torsion rectangular geometry.

The following geometry-specific factors affect the operating range of torsion rectangular geometry:

Thickness of sample (stress constant K_τ and strain constant K_γ)

Width of sample (stress constant K_τ and strain constant K_γ)

Length of sample (strain constant K_γ)

Additionally, the following instrument-specific factors affect the operating range of all geometries:

- Minimum torque that can be measured by the transducer
- Transducer compliance
- Maximum strain that can be generated by the motor

To calculate the minimum and maximum G^* that can be measured by each transducer type using the torsion rectangular geometry, use the following equation:

$$G^* = \left(\frac{K_\tau}{K_\gamma}\right) C \qquad (4\text{-}1)$$

where K_τ = Stress Constant

K_γ = Strain Constant

and C is computed from the following:

Transducer	C for G^* MAXIMUM		C for G^* MINIMUM	
	Equation	Values	Equation	Values
2K STD 2K FRTN1	$C = 0.1\left(\frac{1}{J}\right)$	J = 2.60e-06	$C = \frac{M_{min}}{\theta_{max}}$	C = 4; ARES/RDA2 (2K STD) C =0.4 (ARES/RDA2 with 2KFRTN1 in 200gm-cm mode)
NOTE: The values for M (g•cm) and θ (rad) for the instrument Transducer and Motor are found in the specification tables in Chapter 1 of the instrument manual. If you need assistance, contact Patel Scientific for the exact specifications for your instrument.				

Using a spreadsheet application such as Microsoft® Excel™, you can use the equations above to plot the range of complex viscosity that can be tested for a given geometry/transducer combination as follows:

1) Calculate G* MAXIMUM and G* MINIMUM (using equation 4-1) for a sample of fixed length and width and the minimum and maximum thickness the fixture can accommodate.
2) Generate an X-Y scatter plot of sample thickness (Y axis) versus complex modulus, G^*, (X axis).

The region between the upper and lower limits of operation is the range of complex modulus that can be tested .

Coefficient of Thermal Expansion (α)

When testing at other than ambient temperatures, the coefficient of thermal expansion for Torsion Rectangular geometry is defined as:

$$\alpha = \frac{\Delta L}{\Delta t}\left(\frac{1}{L_0}\right)$$

where $\alpha =$ Coefficient of Thermal Expansion $\left(\frac{1}{{}^\circ\mathrm{C}}\right)$

$\Delta t =$ Change in temperature ($^\circ$C)

$L_0 =$ Original length of sample (mm)

$\Delta L =$ Change in length of sample (mm)

Positive ΔL indicates increasing sample length

WARNING

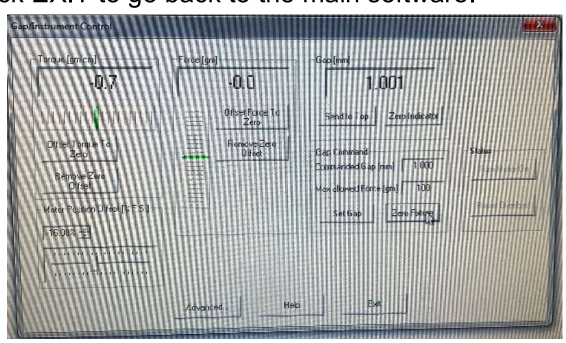
POSSIBLE PERSONAL INJURY
POSSIBLE DAMAGE TO INSTRUMENT

This is a high-torque motor. Turning on the motor while in dynamic mode causes the motor to snap to dynamic zero position at a high velocity. This can cause severe damage to the transducer and/or personal injury. To avoid damaging yourself and the transducer:

- **Never turn on the motor while a Torsion sample is loaded.**
- **Keep hands clear of the motor.**

Torsion Fixture Installation (without sample)

1. Use the UP button on the Test Station panel to raise the stage to the loading position.
2. Verify that the Motor is ON (in the software Control Panel screen) and the motor is in **Dynamic Mode** ***(****Control Menu> Motor Mode: Dynamic****)****.*
3. Mount/Install the LOWER (Shorter) fixture on the Motor. (**Note**: Tool PRT Assembly used with Parallel Plate is to be removed when using this new Torsion Fixture. The Tool PRT Assembly can't be used with this Torsion Fixture)
4. Mount/Install the UPPER (Longer) fixture on the Transducer.
5. ***Zero out any residual Torque and Normal Forces on the ARES. The method to Zero Torque and Normal for ARES V1 through 5/15 is different than ARES V6/V8.***
   5.1. For ***ARES V1-V5 machines***, press the XDCR Zero Button under the blue display of the machine.
   5.2. For ***ARES V6/V8 machines***, open the Gap/Instrument Control Screen in the software and click on **Offset Torque to Zero** and click on **Offset Force to Zero.** Then Click EXIT to go back to the main software.



6. Using the stepper control buttons, lower the stage to a point where the fixtures are close to each other, but not touching (i.e. a Gap of about 2.0mm).
7. Use the "Motor Position Offset" button (either under the Blue Scree or in the Gap/Instrument Control screen) to insure that the upper and lower fixture openings are aligned.
8. Raise the stage to provide sufficient room for your sample loading.

Torsion Sample Loading

Refer to 5 and Figure 6 during the following procedure.

1) Measure and record in the tool set up form (accessed from the "Edit Geometry" button in the *Edit/Start Instrument Test* function) the following sample dimensions:
   - Width
   - Thickness
   - Length
2) Select a matching pair of setting anvils (based upon sample thickness) and secure them in the upper and lower tool. Please note that each setting anvil is machined in such a way as to provide mounting for two different sample thickness ranges. A "nominal" thickness (roughly the center of the clamping range) is stamped on two of the anvil faces (opposite sides). The setting anvil should be mounted such that the desired "nominal" thickness is visible from the outside "back" of the tool (opposite the actual sample).
3) Place the sample into the lower fixture. Center the sample in the tool using the reference lines scribed in the setting anvil and sliding clamp. Partially tighten the clamp (using the adjusting screw) to hold the sample.
4) Lower the stage until the upper fixture is about 1/4-inch from the sample.
5) Use the Motor “Strain Offset" dial on the Test Station Left panel to radially align the sample with the upper fixture if necessary.

CAUTION

POSSIBLE DAMAGE TO INSTRUMENT

In the next step, do not generate a Torque or Normal Force greater than 50% of full-scale. Failure to observe this caution may result in damage to the transducer.

6) While confirming the sample fits into the upper fixture, lower the stage until a compressive (upwards) Normal Force of about 10% of full-scale is generated. If the sample is not aligned properly, re-raise the stage and realign the sample and fixture using the "Motor Strain Offset".
7) Insure (visually) that the sample is completely inserted into the fixtures.
8) Tighten the lower and upper sliding clamps (using the adjusting screw) to the desired torque using the torque screwdriver. **For Phase Angle Calibration using supplied Steel Sample use 60 cNm setting on the adjustable Torque Wrench*
9) Raise the stage until a Tensile (downwards) force of approximately 10% of full-scale is generated. Please note that this tension level is a general recommendation only, and the user should set the tension level according to the sample characteristics. When using the AutoTension feature, adjust the stage so that the normal force is zero.
10) Using the "Motor Strain Offset", adjust the motor position (CW or CCW) until the displayed torque meter’s needle is at zero.
    DO NOT touch the "Torque Zero".
11) Use the ***Hold*** function under the Control pull down menu when changing temperature. If you are using Steel to check phase angle, the sample size will prevent you from closing the oven. So for that reason, skip this entire step, during Phase angle check.

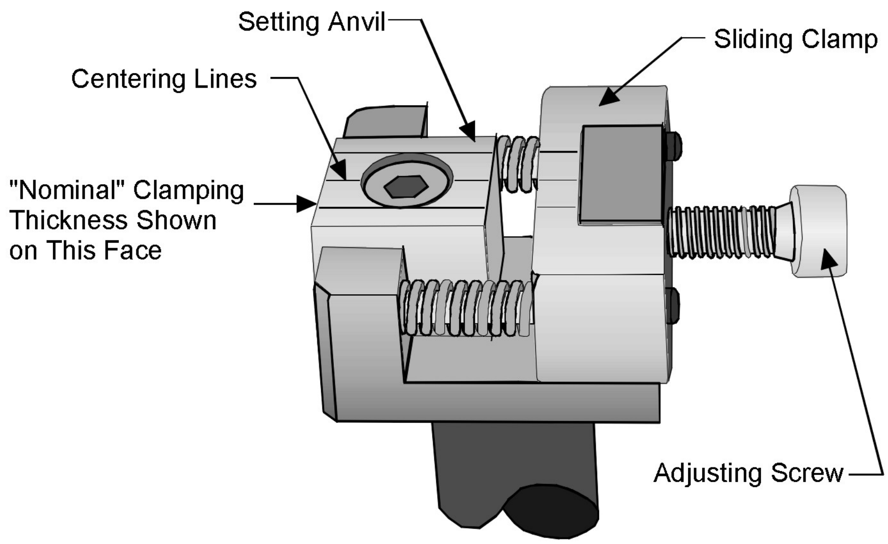


Figure 5 New (**V1**) ARES Torsion Rectangular Tool (with Springs) Details.

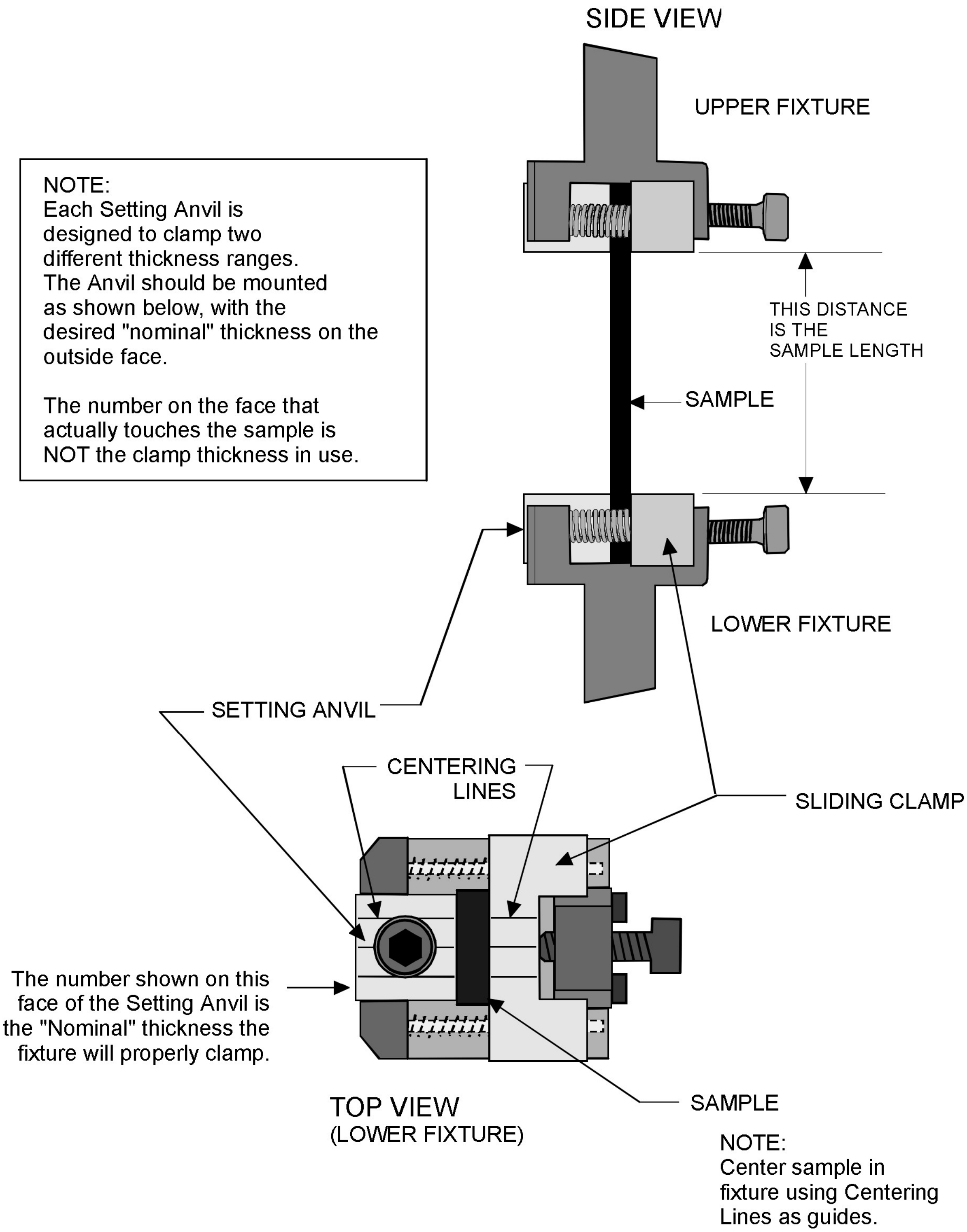


Figure 6 New (V1) ARES Torsion Rectangular Fixture with Sample Loaded.