

## TST350 - Tensile Stress Testing System

Accurately Characterize the tensile properties of your sample relative to temperature utilising the 0.001N sensitive force transducer and capture high resolution images of the structural changes.

### Features and Benefits

The TST350 is built with two precision ground stainless steel lead screws to maintain perfect uniform vertical and horizontal alignment. Sample jaws move in opposite directions to maintain sample in both reflected or transmitted microscope fields of view. This also means other transmitted techniques such as X-Ray, can be used.

As is expected of Linkam stages, temperature control and accuracy is second to none, with a range from  $-196^{\circ}\text{C}$  to  $350^{\circ}\text{C}$  with  $0.01^{\circ}\text{C}$  control and up to  $60^{\circ}\text{C}/\text{min}$  rates, with virtually no temperature feedback to the measurement of force.

Samples can be quickly loaded into the jaws and a test run can be performed in seconds. The data feedback from the force transducer, designed and built in house, can be used to display an online plot of the force/distance when the jaws are moving at constant speed or when speed is varied to maintain a constant force.

Speed of jaws, force applied and distance moved can all be varied relative to the temperature.

The sample chamber is sealed and can be controlled with various inert gases via the precision click fit valves built onto sides of the stage.

The new T95-Linksys temperature controller with LCD touch screen control is used to quickly program a temperature profile or change speed/force settings by simply tapping the onscreen controls. The system can be fully controlled via PC by the Linksys 32X system control software which displays and saves online plots of temperature/force/distance.

### System Options

There are two ranges of force transducer available, depending on application you will need to specify either:

**0 to 20N with 0.001N resolution**

**0 to 200N with 0.01N resolution**

#### Electrical Connections

Both of these system options are available with internal electrical connections which enable you to make electrical measurement on the sample during a tensile experiment.

#### Cooling

If you require cooling below ambient, the TST-LNP95 cooling system is required. The LNP95 cooling pump communicates with the T95 system controller and varies the pump speeds to give a precise flow of liquid nitrogen from the 2L Dewar (supplied), to enable linear cooling speeds from  $0.01$  to  $60^{\circ}\text{C}/\text{min}$ . The exhaust dry nitrogen is then recycled through the pumps and used to keep the tubing flexible and purge the sample chamber to eradicate condensation. (All fittings and Dewar are supplied with the pump).

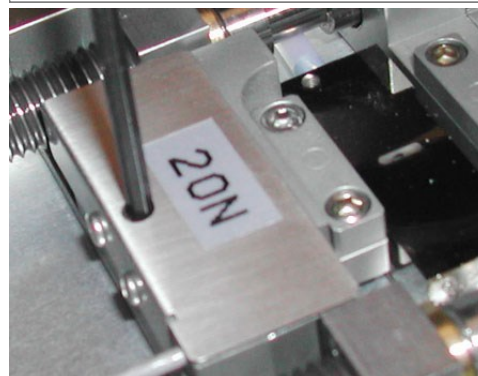


TST350 system shown here with the optional TST-LNP95 cooling system

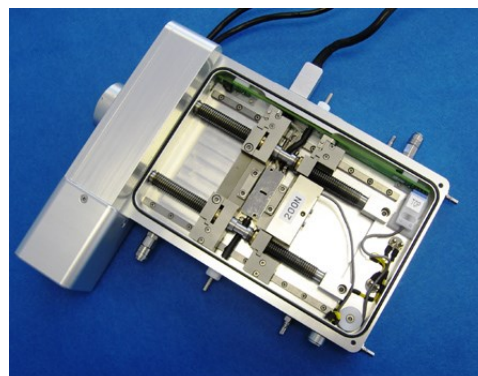
Visit Applications Notes section on website to download;

**Dr. Ashish Lele application note on the Essential Work of Fracture (EWF).**

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Fitting the 20N Force Transducer



TST350 stage fitted with 200N force transducer

## Optical Specifications

The TST350 is designed to be used with an upright microscope, where the objective lens is above the sample. The stage can also be mounted on IR, Raman and X-Ray instruments.

When working with temperature controlled stages, it is necessary to use long working distance objective lenses. If viewing the sample using transmitted light you also require a long working distance condenser lens.

The objective lens is isolated from the sample by the stage lid window which is a fixed distance from the heating/cooling element. In the TST350 this distance is 7.5mm, as seen in the diagram opposite. We recommend that you use an objective lens with at least 7.5mm working distance.

The condenser lens is isolated from the sample by the stage base plate window and the thickness of the heating/cooling element. In the TST350 this distance is 12.5mm.

Linkam make condenser extension lenses for many types of condenser, please select the condenser extension lens from the optical accessories section of our website.

## Attaching TST350 to Microscope

Upright microscopes whether standard optical, or part of a Raman or IR system, usually have an XY table or circular POL table to move the sample relative to the objective lens. These tables are mounted to the microscope sub-stage and need to be removed when using this hotstage.

Linkam manufactures different stage clamps to attach the TST350 stage to many different brands of microscope. The stage clamps are required to adjust the position of the hotstage relative to the light path of the objective lens.

Select the stage clamps you require from the 'Selecting Stage Clamps' section on page 4 of this brochure.

## Increase Capability Options

### Linksys 32X-DV (Digital Image Capture) and Digital Camera

Add digital capture to the Linksys 32X system controller software and one of the range of Q-Imaging digital cameras to enable time lapse image capture including all T95 data saved with the image. Quickly find single or groups of images by dragging a box around an area of the time/temperature graph or scrolling through the gallery. Create movies of experiments and add scale bar, annotations, and measurements. (See 'Software and Image Capture' on our website for more information).

### Imaging Station

Loading a sample in the TST350 requires exceptional spatial access to the sample. The objectives on a standard microscope compromise this access. The Imaging Station has a hinged arm that enables the optics to be retracted out of the way and hence allow full access to the tensile jaws and hence sample loading.

Free up time on your research microscope by attaching your TST350 stage to the Linkam Imaging Station instead. A long working distance condenser is built into the base with polarizer and diaphragm. A 100W halogen light source and C-mount for a camera is also supplied. (See 'Imaging Station' on our website for more information).

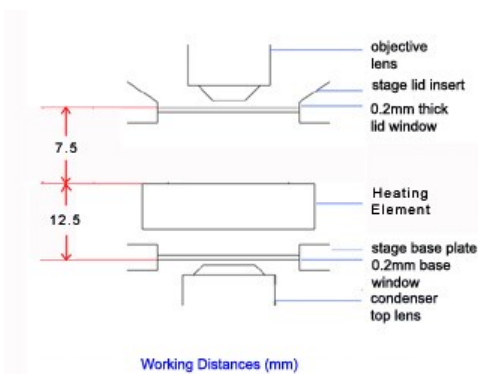
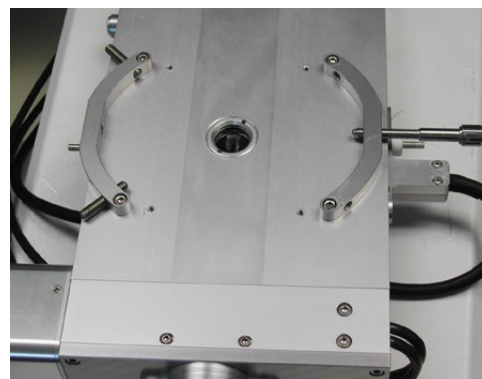


Diagram of objective lens and condenser lens working distances.



Stage clamps attached to base of TST350 fit into circular dovetail. Clamps for other substage types are available.

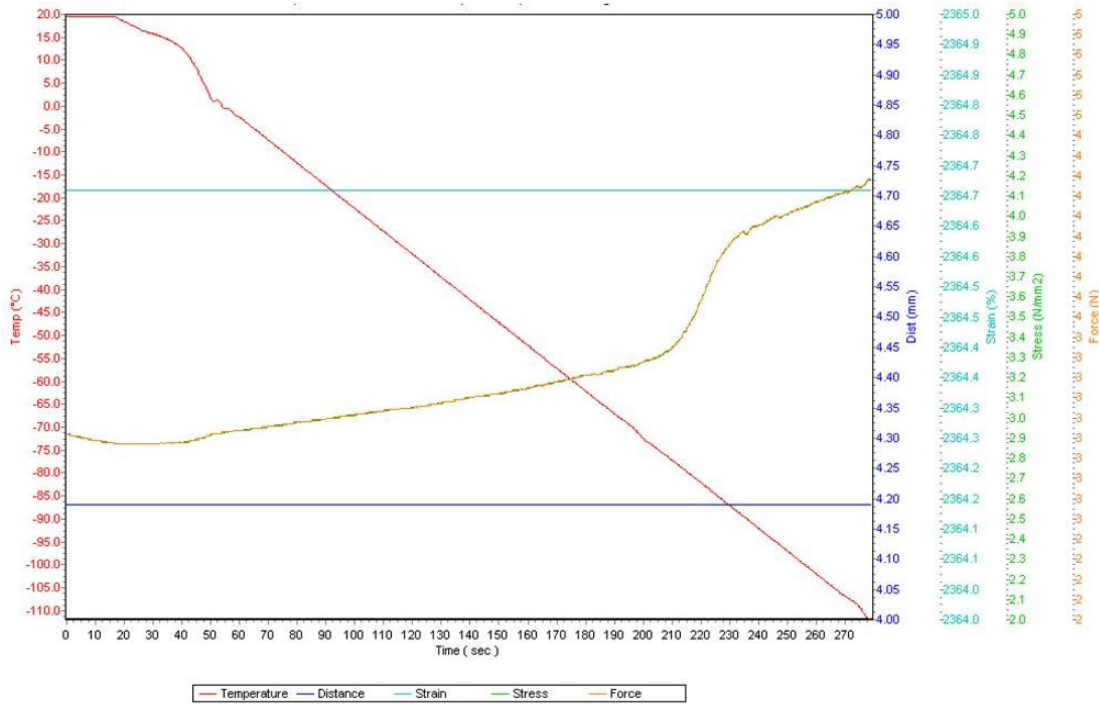


Linkam Imaging Station. Optics are tilted back to allow easy access to sample

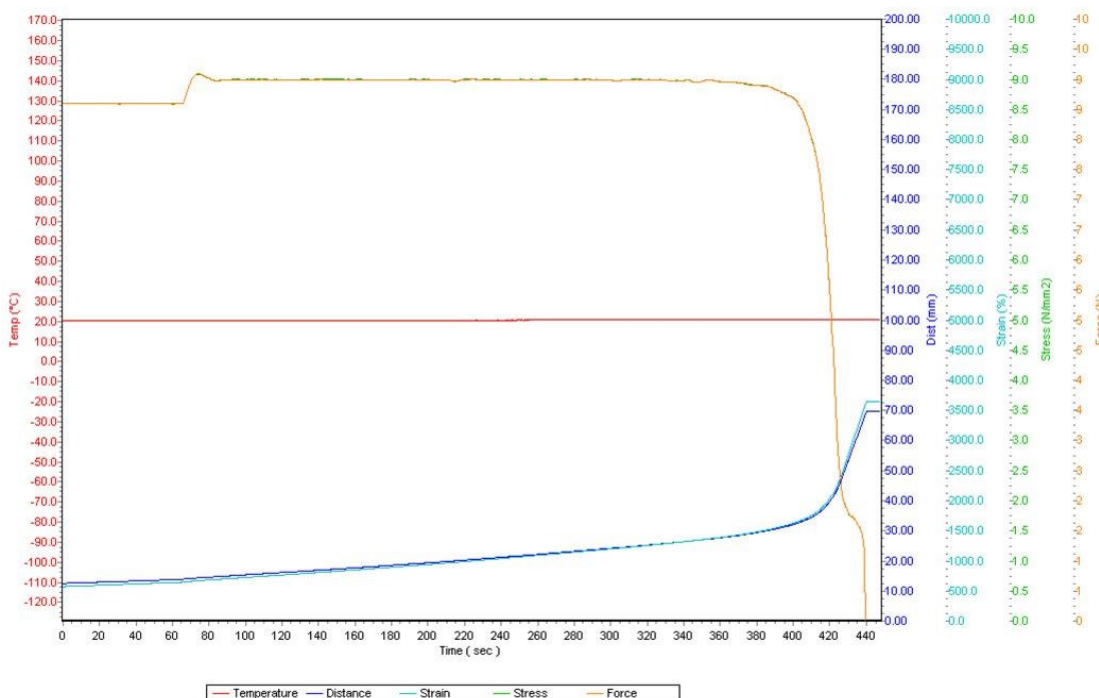
### TST350 Data Plots

This graph generated by the Linksys 32 DV software shows a tensile testing experiment of 0.34 mm thick and 9mm wide Silicon Rubber sheet supplied by Samco Silicon Products.

Using the TST350 and cooling down from ambient to -110°C at 30°C/min with a starting tension of 2.9N the Tg or brittle temperature can easily be determined as the gradient changes on the force plot at -73°C in agreement with the manufactures specification for the silicon.



This graph shows constant force feedback on a sample of 0.05mm thick, 9mm wide film with a constant force of 9N. To achieve this constant force the velocity is controlled by a PID control loop. You can see the distance/time plot changing from 12.58mm to around 28mm quite linearly and then there is a rapid change in speed as the sample stretches beyond the elastic limit and approaches the breaking point.



## Specifications

- Simple mounting plate for optical microscope
- Sample easily loaded into jaws
- Sample width: 0.001 to 22mm
- Sample thickness: 0.001 to 2mm
- Minimum sample length: 26mm
- Maximum travel: 80mm
- Tensile speed range: 1-1000um/s
- Tensile force range: 0.0N to 20N or to 200N
- Force resolution: 0.001N or 0.01N
- Positional resolution: 10um
- Objective working distance: 7.5mm
- Condenser working distance: 12.5mm
- Temperature range: -196°C to 350°C
- Temperature control rates: 0.01 to 60°C/min

## Selecting Stage Clamps

**Select a suitable Stage Clamp to mount to your microscope substage. Stage clamps are listed by microscope make and model.**

### ***Olympus Upright Microscopes***

BX series — 9548 curved clamps

### ***Nikon Upright Microscopes***

E50i, E55i, E80i, — 9548 curved clamps

E400, E600 — 9548 curved clamps

Optiphot 1 & 2, Labophot 2 — 9548 curved clamps

80i/90i with substage for Mechanical stage (not rotatable) — 9785 adapter plate and clamps

80i/90i with Rotatable Mechanical stage — 9564 adapter plate

### ***Zeiss Upright Microscopes***

Axiophot, Axioplan, Axioplan 2, Axioskop 2, Axioskop 40 — 9564 clamps

Axiomager — 9784 clamp ring

### ***Leica Upright Microscopes***

DMLB/M & ATC200 — 9548 curved clamp

DM1000, DM2000, DM2500, DM4000M, DM5000 and DM6000M — 9788 adapter plate and clamps

## Linkam Complete Temperature Control Solution

### What do you need for a complete solution

#### Select Standard System

Either: **TST350 - 0-20** (includes TST350 stage with Force range 0 to 20N, with 0.001 resolution, T95-Linksys system controller and Linksys 32X System control software)

Or: **TST350 - 0-200** (includes TST350 stage with Force range 0 to 200N, with 0.01 resolution, T95-Linksys system controller and Linksys 32X System control software)

#### Or Select Electrical Connection System

Either: **TSTE350 - 0-20** (includes TSTE350 stage with Force range 0 to 20N, with 0.001N resolution, 4 internal spring clip electrical connections with external connector, T95-Linksys system controller and Linksys 32X System control software)

Or: **TSTE350 - 0-200** (includes TSTE350 stage with Force range 0 to 200N, with 0.01 resolution, 4 internal spring clip electrical connections with external connector, T95-Linksys system controller and Linksys 32X System control software)

#### Add additional force transducer

Choose either 0-20N or 0-200N

#### Add Cooling Option to extend range from Ambient to $-196^{\circ}\text{C}$

LNP95 (includes tubing, 2L Dewar and siphon)

#### Add Condenser Lens if using transmitted light

See website 'Condenser Extension Lenses'

#### Add Stage Clamp to mount to microscope sub-stage

See 'Selecting Stage Clamps' on the previous page to select clamps specific to your microscope.

#### Add the Digital Video Capture Option

Linksys 32-DV (requires Q-Imaging Camera)

#### Add Q-Imaging Camera

See website 'Q-Imaging Cameras'

#### Add Linkam Imaging Station

Alternative option, to be used in place of your existing microscope for temperature controlled microscopy, includes 10X lens, polarizer, analyzer, long working distance condenser and 100W halogen lamphouse. See website 'Imaging Station'

## Suggested Spares

The Purchase of spares to avoid downtime with your stage and eliminate future shipping costs.

Part No.	Part Name	Part Description
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<b>9571</b>	<b>TST-20</b>	Force Transducer 0-20N with 0.001Resolution
<b>9571</b>	<b>TST-200</b>	Force Transducer with 0-200N with 0.01 Resolution

Part No.	Part Name	Part Description
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<b>22222</b>	<b>TST Kit</b>	<b>Spare Windows for Lid, base and samples</b>
SRR		Silicon Ring Set for Lid and Base, set of 4
W22G		22mm diameter Glass Lid Window (0.17mm thick) Box of 50
W22G0.3		22mm diameter Glass Base Window (0.3mm thick) Box of 50
TCH		Tube Clip Holder (for Nitrogen de-fogging stage lid tube, for TST-LNP95 cooling system)
TST-OLID		Nitrile 'O'-ring for Lid
HX2.5		Hand Tool 2.5mm
TST-CLP		Sample Clamp with Screws
TCO		Cover Lid to fit on block for accurate temperature