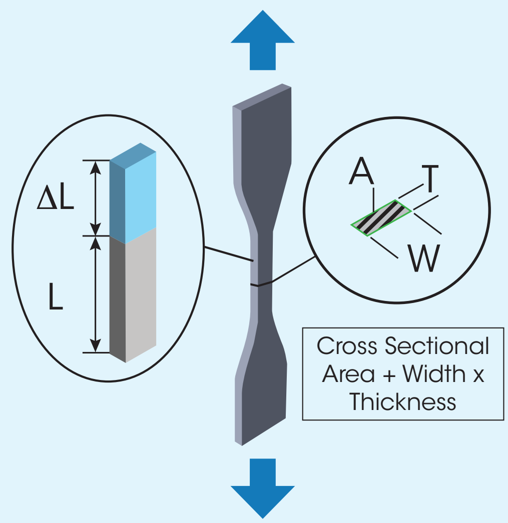
ElectroForce™ Apex 1
Mechanical Testing Instrument

Mechanical Testing

Mechanical testing is critical to ensuring the performance and longevity of your materials and products. Mechanical testing can be used to evaluate samples under relevant conditions including different temperatures, loading mechanisms, and rates. Performing mechanical testing on your materials and products can accelerate development by limiting build/test cycles and preventing premature failure of your products after they are launched.

Using the ElectroForce Apex 1 Instrument for material development can provide quick measurements of strength and durability and help you assess the effects of any changes in formulation and processing. The following mechanical properties can be evaluated using the ElectroForce Apex 1 Instrument:

- Elastic (Young's) modulus
- Ultimate strength
- Fatigue life
- Stress relaxation
- Fatigue crack growth
- Yield strength
- Elongation at break
- Creep compliance
- Fracture toughness

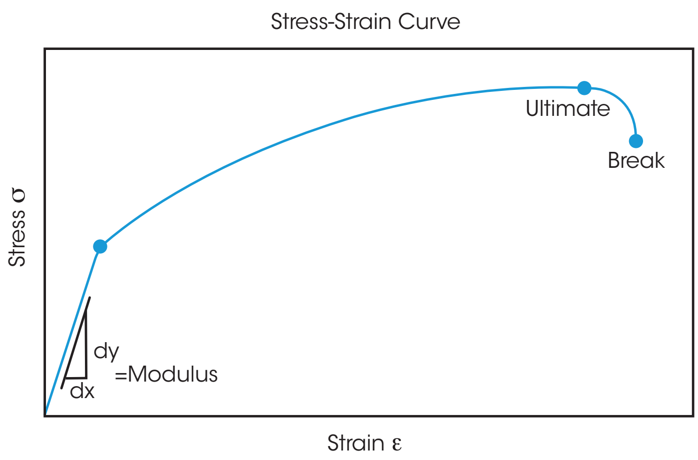


Monotonic and Fatigue Testing

Material strength and durability testing is increasingly important for accelerating development of products in demanding applications, from airplanes to construction materials. In the race to develop cutting-edge materials and products, designers and engineers need definitive, application-specific characterization to validate material reliability. Leading labs and manufacturers commonly use monotonic and fatigue testing to inform material selection and design, followed by component and product performance assessments.

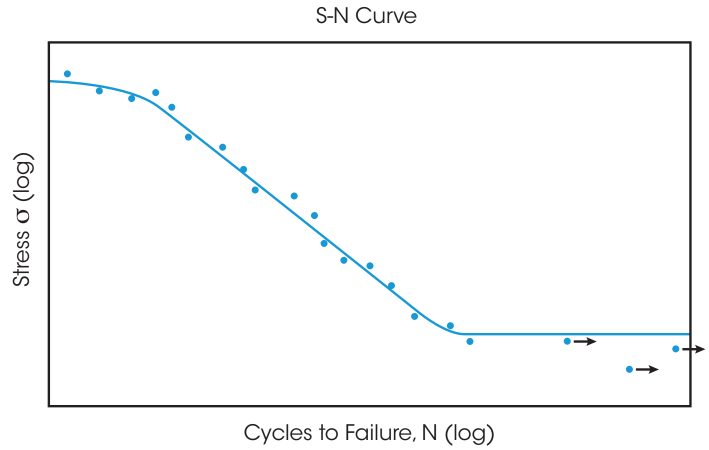
Monotonic Testing

Monotonic tests are easily executed with our streamlined workflow and automated data analysis. ElectroForce Apex 1 Technology enables the user to measure a material's modulus, yield strength and many other properties with limited operator input; only sample dimensions and basic test information are required to run a test, reducing or eliminating any need to set up data acquisition, tune the control system, or manually analyze the data.



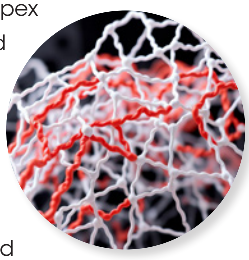
Fatigue Testing

Fatigue testing applies repeated loads and measures the material's resulting damage and failure. Developers commonly use fatigue testing for "Fatigue to Fracture", evaluating when the material fails, or "Test to Success" to ensure their material can perform under application conditions. Fatigue testing can be performed in all the same deformation modes as monotonic testing. Fatigue evaluation commonly involves a series of fatigue tests at different cyclic stresses to create a Stress-Cycles (S-N) curve which represents a material's expected life at various stress levels.



Together, monotonic and fatigue testing offer a detailed analysis of polymers' strength and durability for a wide range of applications, especially when combined with realistic temperatures and environments during testing. Employing monotonic and fatigue testing early in development can reduce costs by identifying and eliminating weaknesses in material selection and design before it becomes very costly in the validation or even the post-launch phase.

Polymer Application - Sample Data



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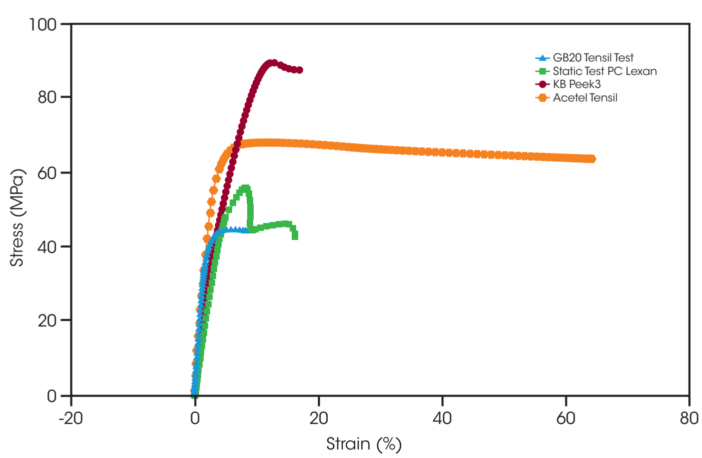
Material properties can be reviewed seconds after test completion. Intelligent Analysis analyzes monotonic test data and quickly reports elastic modulus, yield strength, ultimate strength, and additional properties, including customization for your material and test goals. Analysis capabilities for ASTM D638, ASTM E8, ASTM D790, ISO 527 and other international standards are included and can be adjusted for your specific needs.

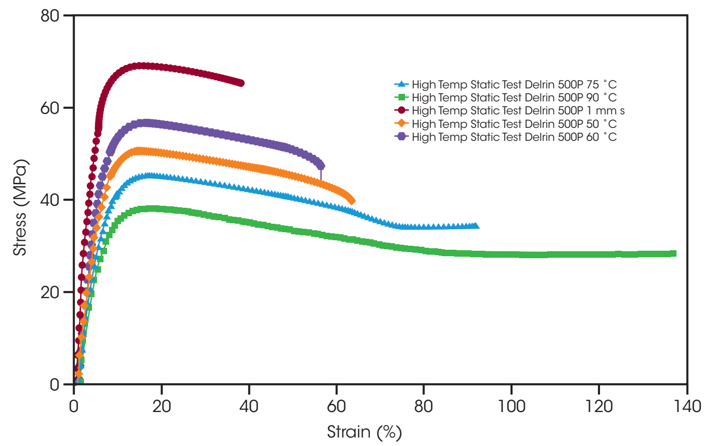
Tensile Properties of a Range of Polymers

Monotonic tensile tests (AKA tensile tests) provide important information about a material's mechanical response as it is slowly deformed. The sample is deformed at a constant strain rate and the stress response is measured by the instrument. Tensile tests provide a reliable measurement of the material's modulus, strength, and elongation. As this figure shows, the characteristics shown in the stress-strain curve also provide significant insights into a material's properties. Understanding a material's complete stress-strain curve is important to know how its response will change as it is stressed to its maximum strength and beyond.

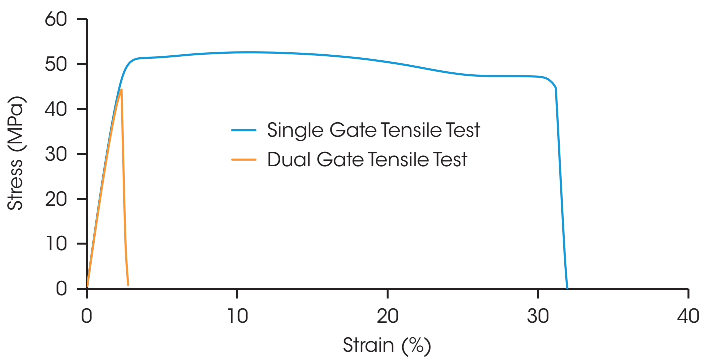


Temperature Effect on Tensile Properties of Acetal

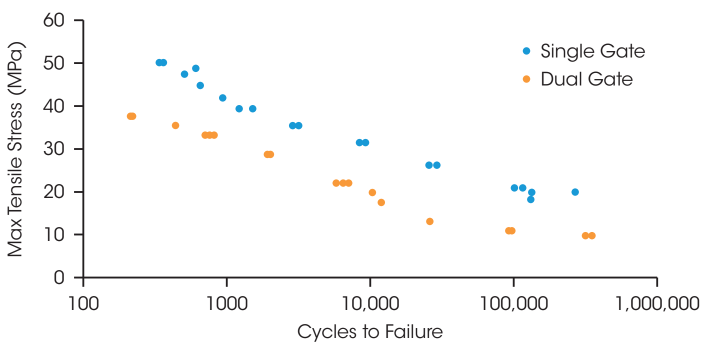
The properties of polymer materials are highly influenced by temperature. As this stress-strain data shows, increasing temperature affects the material's properties in a variety of ways. The acetel material shows that increasing temperature results in a lower modulus (indicated by the slope of the initial line), lower strength (lower peak stress) and higher elongation (strain at break). Additionally, the material begins to have distinctly different behavior at higher temperatures and strains. Testing at different temperatures is very important to understand how the material will behave across the range of expected storage and operating temperatures.



Single and Dual Gate Sample Tensile Curves



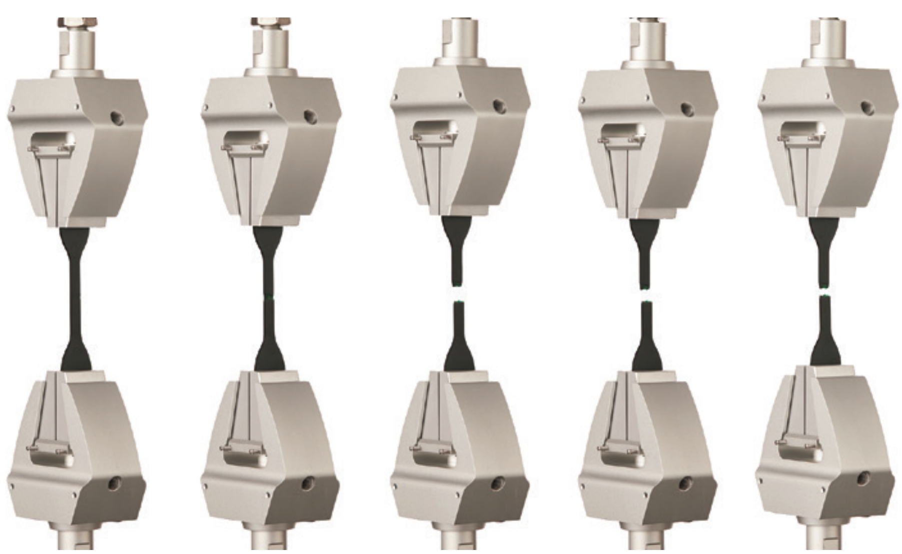
Fatigue Life of Single and Dual Gated Samples



Loss of Durability due to Manufacturing Artifacts

Material properties are typically tested in ideal conditions. This serves to provide a consistent and reproduceable measurement, but it can also tend to overstate a material's ability to perform in a given application. A good example is that standard tensile test "dogbone" samples are molded with a single gate providing optimal material flow and entanglement of the molecular chains. Real parts rarely can replicate the material performance in dogbone form. This data shows the effect on the strength and durability of a material when the sample is molded where the material must flow together in the mold creating a knit line.

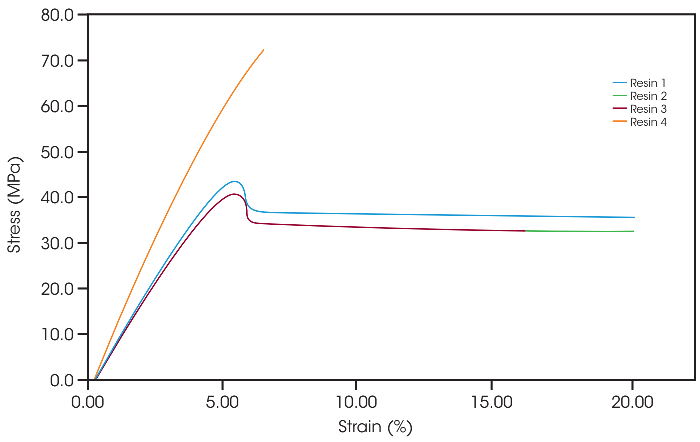
This tensile testing data shows a marginal loss of strength, but there is a significant loss of elongation. The fatigue testing data is represented as an S-N curve which plots the cyclic stress level (y-axis) to the cycles to failure (x-axis). At a given stress level, the dual gate sample had significantly lower cycles to failure. Other manufacturing artifacts such as voids or filler orientation could have similar effects. It is important to understand a material's performance after it is processed and formed into the real part.

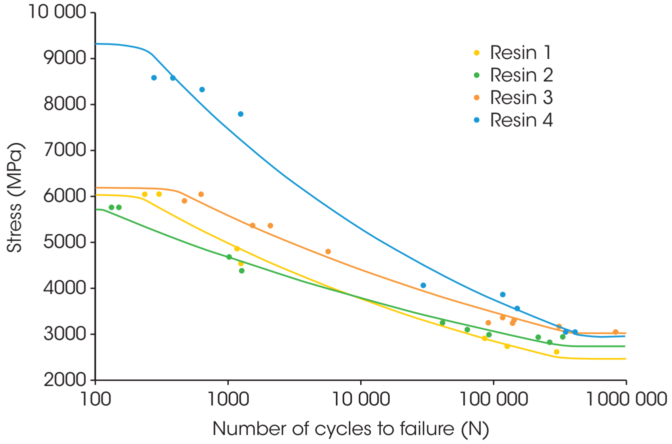


Strength and Durability of Different Material Blends

Polymer materials come in a wide variety of formulations with many options for different blends, different types and amounts of fillers, and various additives for processing and other performance characteristics. Their properties on the datasheet might look very similar, but that does not mean that they will have the same performance.

This data shows three different ABS resin blends and the base SAN resin. The three ABS resins have similar responses in their tensile tests, but significantly different fatigue performance. It is also clear that the best material for fatigue could not be predicted from the tensile testing data.

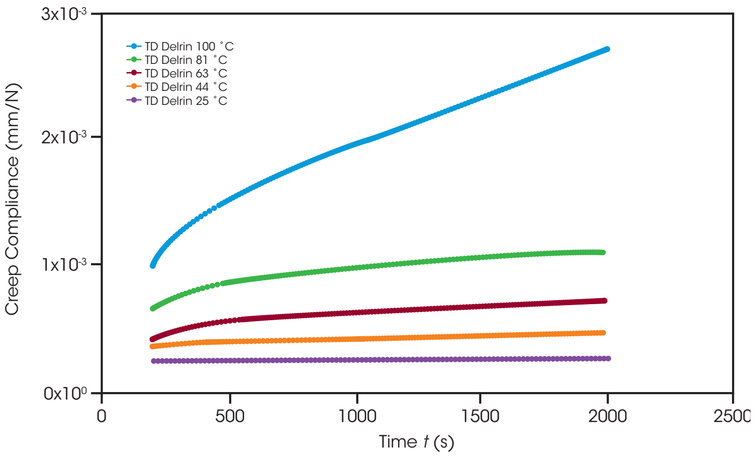




Material Creep Evaluation at a Range of Temperatures

The viscoelastic nature of polymer materials means that they continue to deform under a steady load. This behavior is called creep. Increasing temperatures result in accelerated creep behavior due to the higher mobility of the molecular chains. Creep resistance is often overlooked as an important property of polymer materials. Creep can cause component failure in multiple ways. One way is that the material deforms under constant load and is no longer able to perform its function. The second creep failure mode is creep rupture, where the material has a brittle fracture due to creep.

A more complete picture of a material's creep resistance can be seen by performing successive creep measurements at increasingly elevated temperature. The ElectroForce Apex 1 Instrument is particularly valuable for these types of experiments with its high force capacity and long motor stroke, helping ensure that measurements can be completed on a wide range of materials and use cases.



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