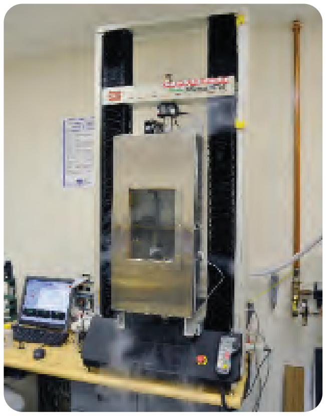
SES
PRODUCT DEVELOPMENT
& ENGINEERING

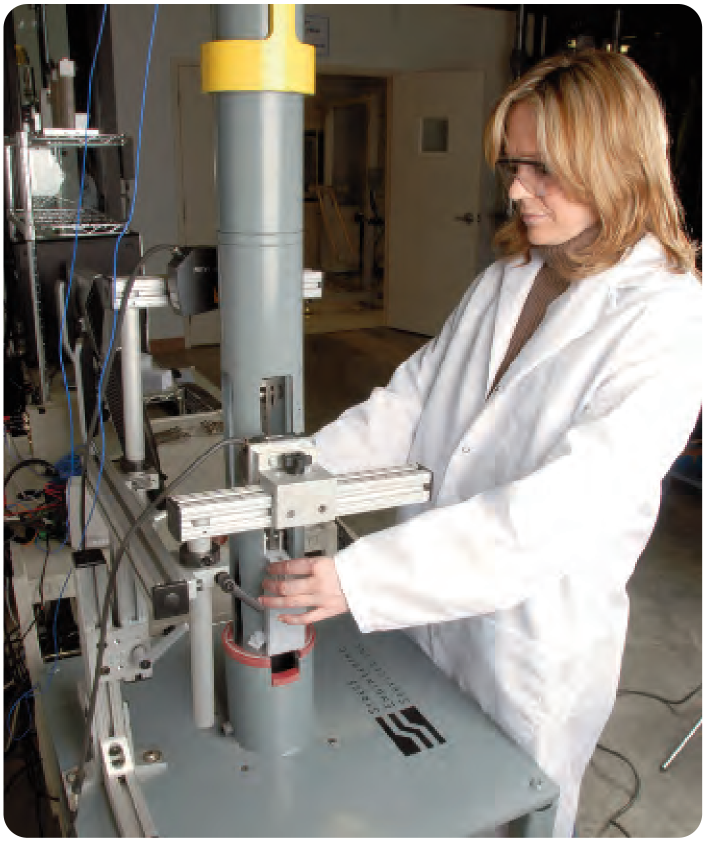
STRESS ENGINEERING SERVICES

Plastics & Composites Testing:
Material Characterization & Failure Analysis

Laboratory-based material testing and characterization capabilities are the cornerstone of Stress Engineering's plastics, rubber and composites design and predictive analysis services.

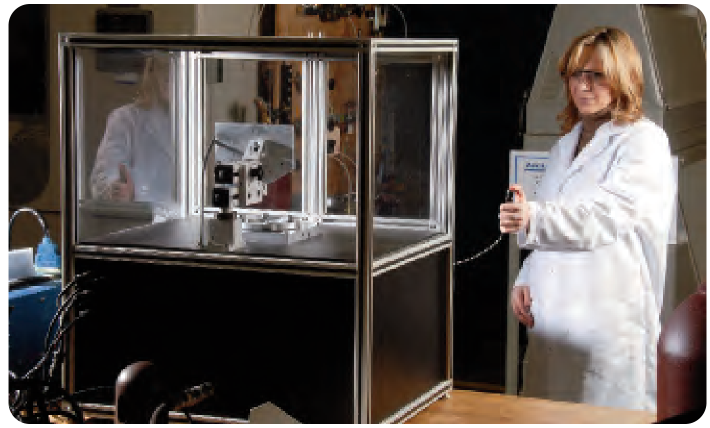
The fact that we use the data we generate gives us a unique perspective on what specific material data and information is needed to design the most robust products and components. SES uses a wide range of specialized tools to test and characterize the behavior of plastics and composites. Data is collected to establish material behaviors and determine which materials are appropriate to use, and when.





High Strain Rate Tensile Testing (HSRT)

This proprietary test machine, developed by SES, is capable of testing at rates on the order of 10,000% per second, capturing how stress, strain and ductility at failure are affected by high strain rate events, such as drop impact. Very early in the development process this test can be used to screen candidate material for a particular design application, or to develop 'material models' for predicting failure using non-linear finite element analysis methods. SES is unique in combining testing capabilities and predictive structural modeling.

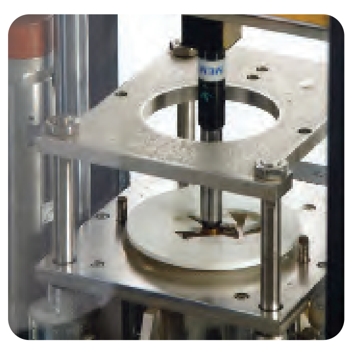


Biaxial Tensile Testing (for film and thin materials)

Failures in most plastic products occur under multi-axial stress/strain states. The effect of this stress state is to reduce the ductility of the materials, which becomes the limiting load scenario for design. To collect data for this important material parameter SES developed a Biaxial Tensile Test system. This equipment captures the behavior of film and thin materials under biaxial tension. It is used to evaluate materials for drop impact applications and other high strain rate events. The test specimen thickness is limited to about 0.040 inch maximum. For thicker sections a variety of notched specimens are available for producing triaxial behavior.

Dynatup Instrumented Drop Impact Test Machine

The Dynatup is an instrumented drop impact test machine. It is also used for biaxial testing because it will accommodate thicker material samples than the Biaxial Tensile Test system. This equipment is used to conduct high strain rate ductility testing.



Dynamic Mechanical Analyzer (DMA)

A DMA measures a wide variety of time- and temperature-dependent mechanical performance attributes on very small material samples. Dynamic properties (storage and loss modulus and tan delta for damping) which are important in product noise and vibration problems, can be measured directly. The machine can also be used to measure creep, relaxation and recovery. The DMA is capable of making these measurements in several different loading modes: tension, compression, bending and shear.

The DMA is also capable of measuring properties over a very large temperature range, -145°C to 600°C, by combining liquid nitrogen cooling on the low end and a high performance furnace on the high end. This allows measurement of thermal transitions (e.g. glass transition temperature), and provides an efficient process to study material behavior over a range of temperatures and strain rates. These data can then be combined through time-temperature super-positioning to create a master curve of material stiffness, which includes strain rates (both fast-drop impact or slow-creep) that are difficult to measure using other means.

Elastomer High Frequency Tension/Compression Test Machine

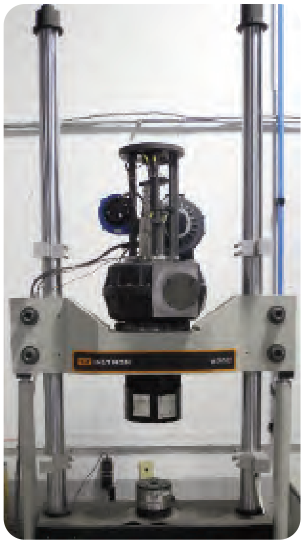
Depending on the required load/displacement, this test machine is capable of cycling a test sample up to 100 hertz. One of the most common applications involves testing of elastomers or other polymers subjected to long term cyclic loading.

Creep Testing of Plastics

Time dependent deformation of polymers is a critical design load case for many products. Sustained loads and elevated temperatures can accelerate creep-related failure mechanisms. SES has more than 70 creep machines/stations that can be used to measure tensile creep properties of polymers and composites over a wide range of temperatures.

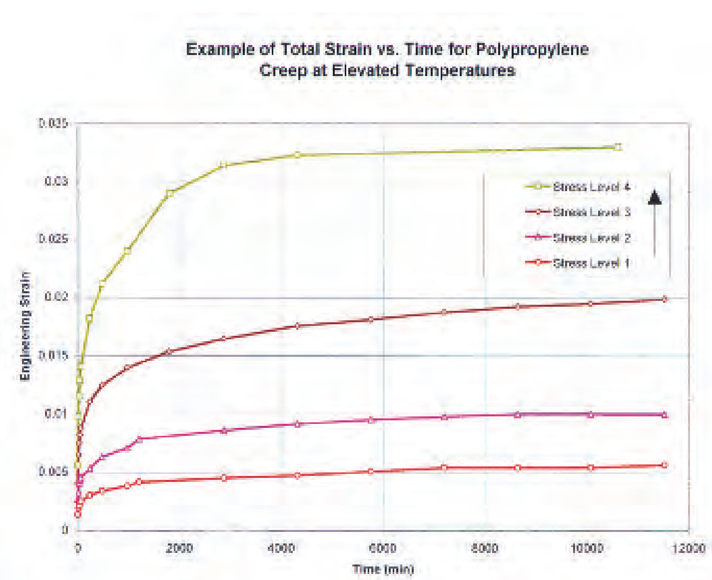
Constant Strain Rate Creep Testing

Most creep testing is load controlled, not strain rate controlled. SES's constant strain rate creep machine will operate at a constant tensile strain rate of one micron per hour. The ability to control strain enables SES to explore damage under cyclic loading and highly redundant conditions. Also, "slow" damage mechanisms in plastics, such as environmental stress cracking are better characterized by slow constrain rate testing.

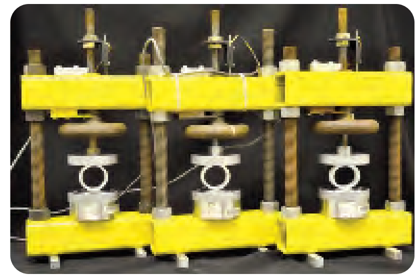


Creep Rupture Testing of Composites

High temperature composite creep rupture testing measures a material's ability to support load over time. This test system produces a constant tensile load in specimens while the time-to-rupture is measured. SES constructed two, ten-station frames that include thermally controlled chambers, which are important because creep rates for polymer-based composites are highly temperature dependent. This temperature dependency is used to accelerate testing, and the data is used in structural calculations to assess design performance or to screen candidate materials.



Stress Relaxation Testing



Stress relaxation test frames measure the loss of force when a polymer is subjected to a fixed deformation, which is the reverse of creep. This is a common condition for plastic assemblies, where sealing features or snap locks are deformed and then held in a fixed position. These data are used to determine the retention of strength over time. Tests are often run at elevated temperature to accelerate the relaxation process.

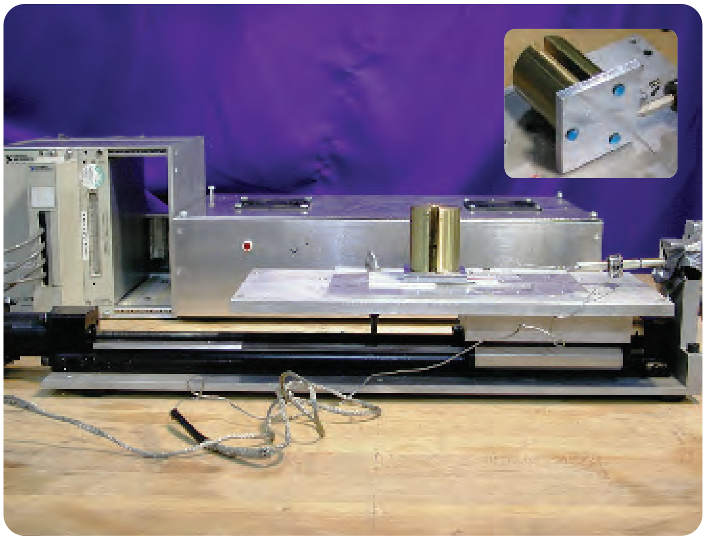
Accelerated Aging of Plastics (In-Service Degradation Mechanisms)

Aging tests are conducted in environmental chambers, with elevated temperature accelerating effective time. This effect is based on the Arrhenius equation, which relates temperature and time. Testing at multiple temperatures can provide a quantifiable acceleration factor. These tests are often done in conjunction with chemical exposure and mechanical loading to understand potential product reliability problems resulting from environmental stress cracking, mechanical loads or material degradation.

The Walk-in Environmental Chamber makes it possible to condition and test large components, or significant numbers of components under extreme environmental conditions (20°C to 80°C, up to 100% relative humidity) for accelerated aging testing.

Accelerated Weathering Testing (AWT)

Extended exposure to UV from sunlight or other sources can cause degradation in the structural properties of most polymers. Although additives have been developed to slow the degradation process, they do not eliminate this problem. Ultimately, a manufacturer of products that will be exposed to the weather must test the performance of their candidate resin systems to 1) make an informed selection of the best resin, and 2) estimate the life of the product.

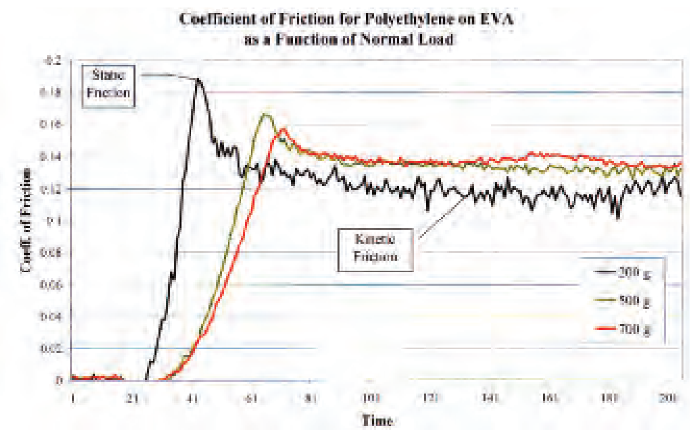


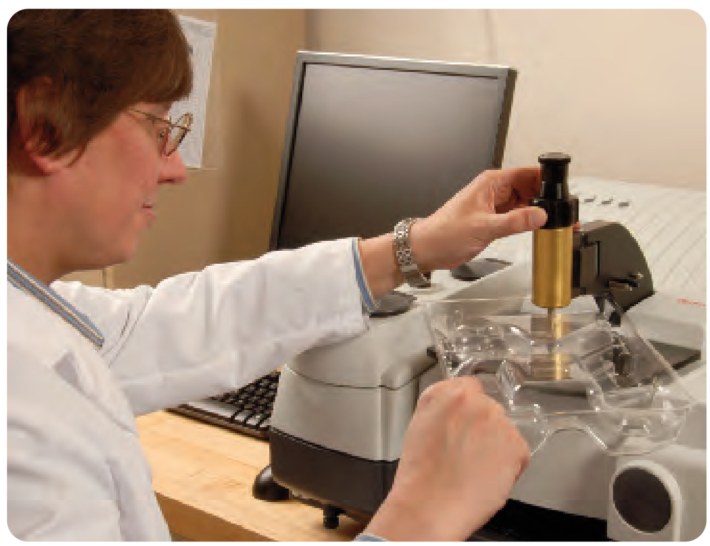
Friction Testing

Real world plastic product design and assembly involves one component sliding in contact with other components. Friction is always a factor in these situations. SES has developed proprietary friction testing equipment capable of testing over a wide range of conditions.

Water Vapor Permeability

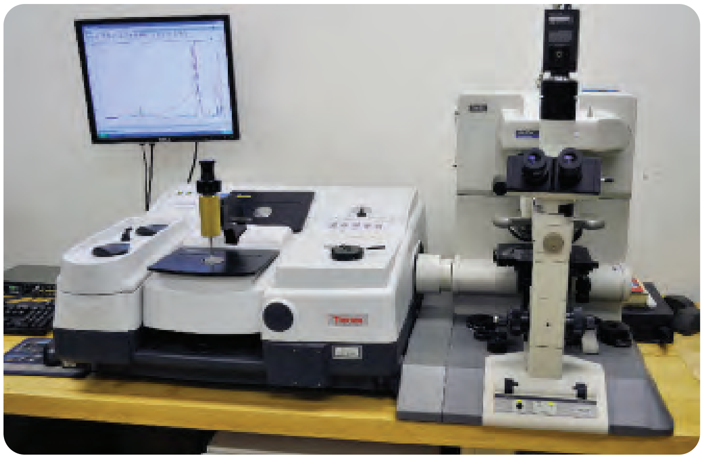
There are many industries where moisture control or gas transmission is critical. Moisture sensitive *foods* and *pharmaceuticals* are sealed to achieve the required *quality, safety,* and *shelf life*. The Mocon Permatran-W is the benchmark standard for measurement of water vapor transmission rates. When used in conjunction with SES's environmental chambers, the Permatran-W is capable of measuring permeation through films and barrier materials over a wide range of temperature (-70°C to 190°C) and relative humidity (10% to 98%). By measuring the permeation rate at the expected real world conditions, sensible material selection can be made.





Fourier Transform Infrared (FTIR)

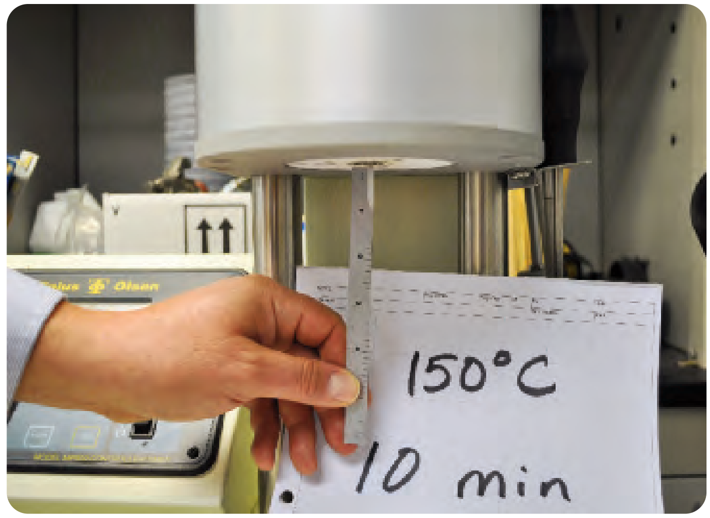
The FTIR uses an infrared laser to capture a material's vibration pattern at a molecular level, which is a fingerprint of the material's chemical composition. Each chemical bond in the polymer chain will have unique vibration frequencies. Materials are identified based on the combinations of frequencies measured. SES often uses the FTIR to monitor a client's resin supply chain, establish material benchmarks and reverse engineer plastic products. Measurements can



be made on a product's surface, which provides a non-destructive technique for sampling. This tool can be combined with a microscope to allow precise selection of measurement location, and to identify trace contaminants, or multi-material structures.

Digital Microscope

Diagnosing plastic failures or inspecting the most minute features of molded plastic parts is essential to the product assessment and failure analysis process. With this specific purpose in mind, SES uses a digital microscope to inspect and document features and failures. The Keyence digital scope is very effective at enabling inspection of clear resins, in addition to those with pigment.

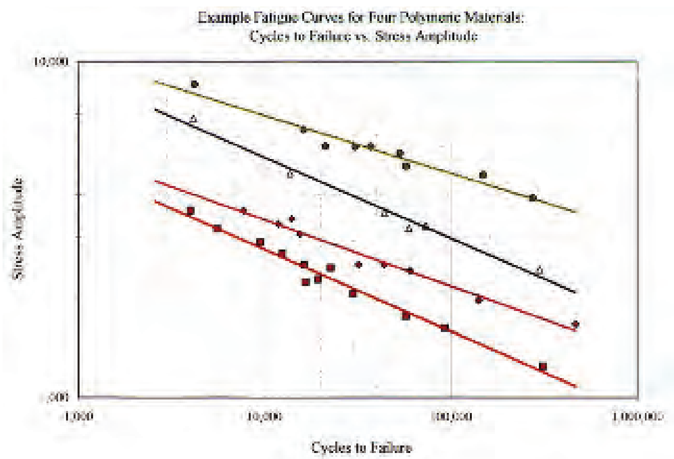


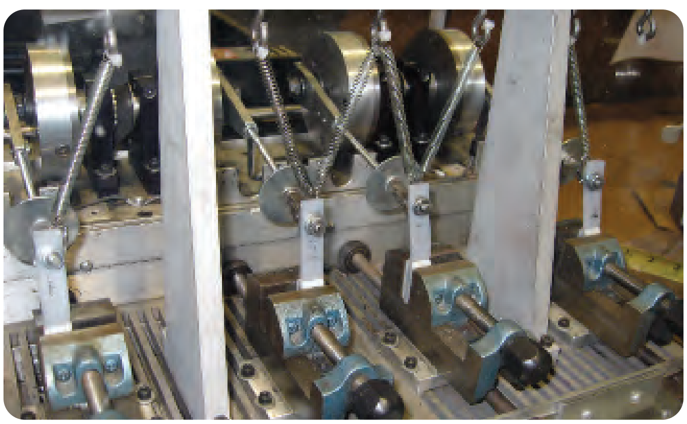
Melt Flow Testing

A melt flow measures a polymer's viscosity at elevated temperature. Melt flow rate is a key specification provided by material manufacturers to identify how easily the material can be processed by injection molding or extrusion. The melt flow is directly related to molecular weight of a material, so the test provides a key indication of durability. The test is also useful for determining if a material has been degraded during processing, or if a material substitution has been made.

Plastic Fatigue

Plastics applications involving cyclic loading are common in machinery-related situations. SES has developed a cost effective approach to generating fatigue data that also enables the study of mean stress effects. These data can be used in conjunction with predictive analysis methods to estimate product life.





Injection Molding Machine for Molding Test Samples

SES's 66-ton Aurburg machine can be oriented horizontally or vertically, offering the capability to do standard injection molding and insert molding. Test specimens can be molded under a wide range of conditions with the goal of simulating processing conditions that can produce damage in materials. This machine is also used for the molding of prototype components.

For Plastics, Composite and Elastomer Materials
Testing & Characterization
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