STRESS ENGINEERING SERVICES INC.

Materials Science & Engineering:
Polymers, Elastomers and Composites

SES offers a full range of R&D, failure analysis and analytical characterization support services.

New Facilities-New Capabilities

The use of polymers, elastomers and composites is growing fast. This growth is not limited to the durable and non-durable consumer and medical products industries, but also includes diverse industries such as manufacturing equipment components, industrial products, oilfield equipment and pipeline repair, to name a few.

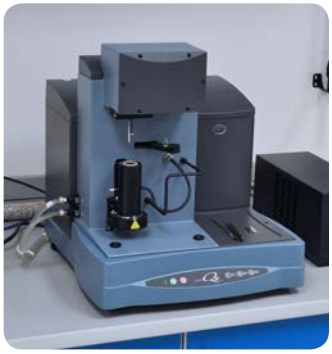
To meet the growing demand for polymer material selection, failure analysis and material compatibility assessment services, SES has invested heavily in staffing and polymer characterization/testing instruments. A new polymer materials services facility has been constructed in SES's centrally located Ohio facility to meet the growing demand for this work. The labs include a broad range of equipment necessary to evaluate the very complex polymer-related materials challenges for our clients.

A Full Suite of Thermal Analysis Testing Instruments

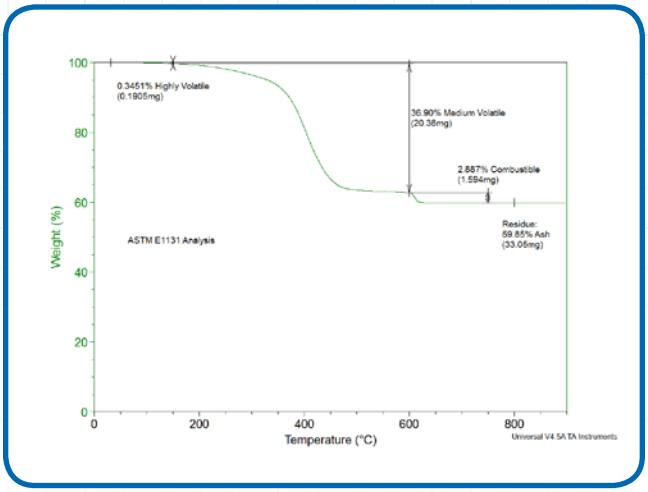
The backbone of a polymer characterization laboratory is a suite of thermal analysis testing instruments. SES has a number of research-quality TA Instruments testing equipment including TGA (Thermogravimetric Analysis), DSC (Differential Scanning Calorimeter), DMA (Dynamic Mechanical Analysis) and FTIR (Fourier Transform, Infrared Spectroscopy). In addition to the ability to fully characterize polymers, polymer composites and elastomers, SES can conduct exposure–based aging investigations as a function of applied stress/strain, temperature and time. Standard exposure-based tests can include about any combination of sustained and variable stress/strain in contact with operating fluid, explosive decompression and high pressure-high temperature (HPHT) aging in corrosive media, sterilization, physical aging, ultraviolet weathering, and simulated life cycle testing.

TGA (Thermogravimetric Analysis)

The TGA is generally used for compositional analysis, determination of decomposition temperature and the development of kinetic models for decomposition. TGA testing, especially through the use of kinetic models, can



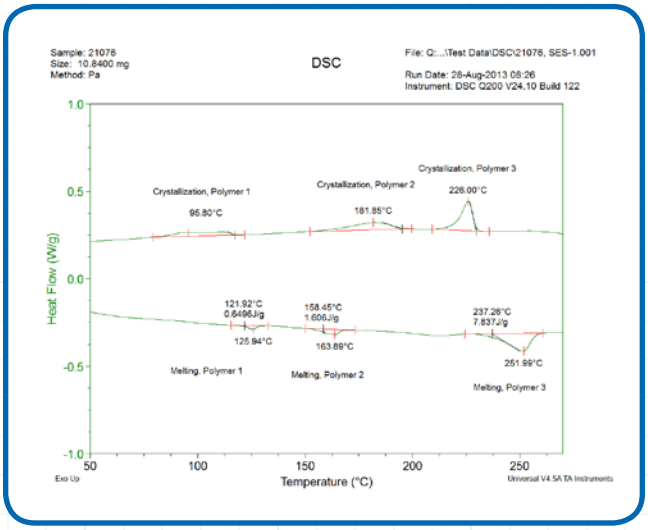
TGA (Continued)



detect degradation induced during aging. This tool is used by SES, in combination with accelerated aging, to anticipate degradation mechanisms that can lead to premature failure.

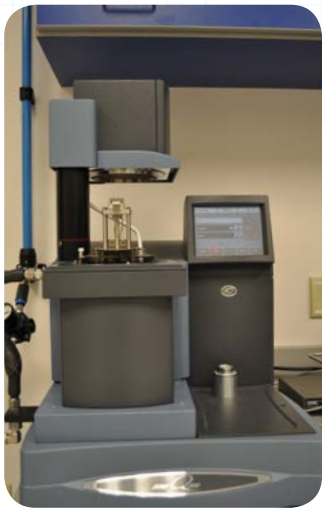
DSC (Differential Scanning Calorimeter)

The DSC is an extremely versatile instrument which produces data for product/component design, failure analysis and material compatibility assessment.

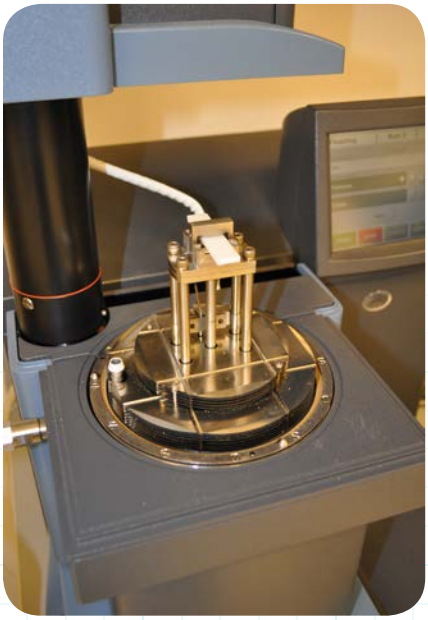


Standardized tests include oxidative induction time, blend compositional analysis, crystallization and melting temperature, glass transition temperature (Tg), the enthalpy of crystallization and melting, and non-isothermal crystallization and melting behaviors. The instrument can also be used to complete more research-oriented evaluations such as determination of thermal conductivity, isothermal crystallization behavior and the development of Avrami crystallization models.

DMA (Dynamic Mechanical Analysis)

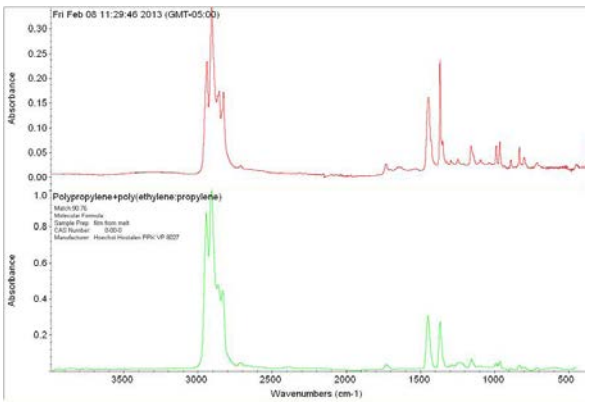


DMA testing can be used to generate both polymer characterization data as well as mechanical performance data - directly feeding the mechanical design process. Mechanical glass transition temperature (Tg) of a polymer can be measured. Tg is often used as a diagnostic parameter to quantify a change in properties after 'real-world' aging (failure analysis) or accelerated aging experiments (material selection for component design). The generation of master curves using time-temperature superposition (TTS) is also a standard test that can be the basis for prediction of creep deformations (i.e. long-term structural performance), using predictive analytical or computational simulation methods. Material damping ('tan delta'), a dynamic performance perimeter can be measured with a DMA. Measuring material damping is particularly useful when evaluating the dynamic properties of elastomers. For composites, a DMA can be used to determine the degree to which a composite has been cured.



FTIR (Fourier Transform, Infrared Spectroscopy)

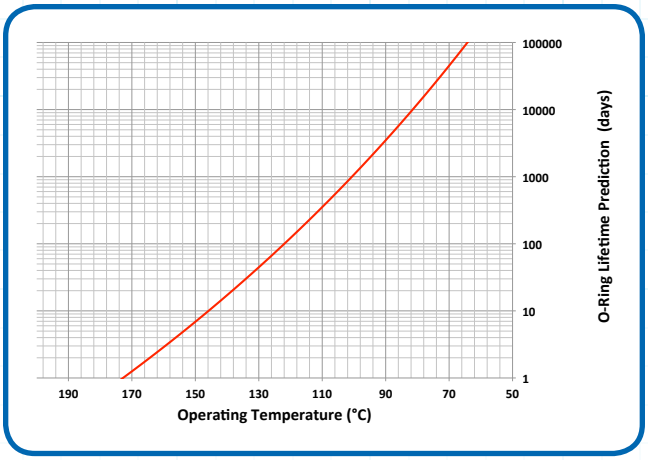
Fourier Transform, Infrared Spectroscopy (FTIR) is an analytical characterization technique that is used to identify unknown non-metallic materials. FTIR makes identification possible because each functional group (C-H, C-N, C-O, etc.) has a specific excitation band when exposed to infrared light. The FTIR technique is used to reconstruct a polymer material and to identify unknown compositions. Advanced sampling techniques can be used to determine degree of



cure in adhesives, transesterification reactions in polyesters, and in some cases it is possible to identify oxidation and decomposition of the organic compounds in polymers. Perhaps the most common usage of the FTIR is for contamination analysis when working to uncover the root cause(s) of a failure.

Elastomer Compatibility Testing

Simply put, elastomer/rubber materials are complex. Their hardness and corresponding mechanical properties change significantly as a function of temperature and chemical environment. Developing a core understanding of the performance of a rubber compound in contact with a pressurized fluid media



is often the difference between success and failure in an application. Even for a defined fluid, the degree of swell changes as a function of temperature. That is, swell at room temperature will be different than at 50°C and again different at 100°C. The mechanical properties, because of the difference in swell, will also be different. Therefore, characterization across a wide-range of conditions is necessary.

Failure can be prevented by understanding the complex interaction between these fluids. In the case of o-ring's that are constrained within a groove, if significant swell occurs, the material can extrude through the clearance gap causing a loss of sealing performance. The oil patch has a variety of mechanically loaded applications including pod-wedge seals or the sealing element in a BOP that can show dramatic changes in mechanical performance as a function of exposure.

SES has developed the ability to conduct compatibility testing of elastomers at elevated temperatures and pressures in a variety of fluid and pressurizing media. SES is capable of extracting test specimens from

Elastomer Compatibility Testing (Continued)

finished product or testing standardized coupons. Typical measurements include the change in mass, hardness, volume swell, and mechanical properties as a function of fluid exposure. SES also conducts explosive decompression testing of elastomers. Analysis of synthetic drilling fluids in combination with a pressurizing media is a standard offering.

Wet Chemistry

As an extension to the analysis of polymers and elastomers, SES conducts chemistry-based analysis of polymers and elastomers. In order to support the ethylene piping industry as well as medical clients who utilize Polyethylene closures that undergo repeated and prolonged exposure to sterilization, SES developed the ability to test gel content. Selective distillation and solvent extractions of polymers was also added to support the medical technologies group. Selective extraction was developed to assist with failure analysis in multiple component systems. Standard soxhlet extraction and separation techniques as well as custom chemical testing are available.