Introduction

The GASP®, or Grazing Angle Surface Polarimeter, is an optical instrument designed to measure SURFACE STRESS in glass products. The procedure is non-destructive, accurate and simple, suitable for in-plant or field testing.

Surface stress is measured for process control of:

Annealed Glass - to assure proper annealing and good cutting properties

Heat-Strengthened and Tempered Glass - to meet product strength specifications

Safety Glass - to validate tempering furnace settings for the desired break pattern or fragment size, which directly correlate to surface stress

Surface Stress levels are generally set for each product in specifications such as ASTM C1048 or other standards. ASTM C1279 details the test methods for measuring surface and edge stresses in heat-treated and annealed glass. The instruments used for these procedures are:

GASP - for Measuring Surface Stress, and

GES-100 Edge Stress Meters - for measuring Edge Stress, also available from Strainoptic Technologies.

GASP Models

The GASP is available in two basic models:

GASP - the standard model is designed for flat surfaces. It can also be used for slightly curved surfaces or bent glass with a radius of curvature greater than 20 inches (500 mm).

GASP-CS - recommended for curved surfaces with a radius of curvature greater than 8 inches (200 mm). GASP-CS features a shorter contact length with the glass surface and is equipped with a stabilizer bar which allows proper positioning on curved surfaces.

Both GASP models can be equipped with a Fiber-Optic or Laser light source. "LASER-GASP" refers to a GASP equipped with a Laser Light Source, which offers the broadest range of surface stress measurement (up to 25,000 psi/180 MPa). The Laser source is battery-operated for greater portability.

GASP and GASP-CS are equipped with a "standard" quartz measuring wedge. However, for low stress products, such as annealed glass, windshields or TV panels, a high sensitivity wedge is a better choice since it doubles the measurement resolution. Both wedge types are interchangeable and may be used with the same instrument.

To select the right GASP for your application, see the Model Options Chart or contact Strainoptic Technologies for assistance.

Ordering Information

All GASP instruments are supplied as complete kits, equipped as follows:

- INSTRUMENT OPTICAL ASSEMBLY
- STANDARD "QUARTZ" MEASUREMENT WEDGE*
- INDEX FLUID (1 ounce)
- CARRYING CASE
- AC POWER SUPPLY/RECHARGER 115V AC
- 220V 50 Hz ADAPTER (export orders only)
- BATTERY PACK (Laser model only)
- MANUAL WITH CALIBRATION CHART
- PRACTICE SAMPLE FOR OPERATOR TRAINING

* The High Sensitivity Wedge can be substituted for the Standard Wedge upon request at no additional charge.
**GASP Model Options**

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<thead>
<tr>
<th>Tempered Glass</th>
<th>Heat-Strengthened Glass</th>
<th>Annealed Glass</th>
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<td>The strength of tempered glass is created by a heating and quenching process which creates a surface layer of compressive stresses, offsetting any tension caused by wind pressure, thermal shock, impact or other applied forces. ASTM C1048 and other specifications require a minimum level of surface compression for glass to be classified as “Fully Tempered”. While higher surface compression assures glass strength, the tempering process also creates tensile stress in the glass mid-plane (see figure below) which should also be controlled. If the tensile stress is too high, the glass may spontaneously rupture if it contains certain inclusions or defects. For this reason, an upper stress limit should be established to avoid potentially serious problems.</td>
<td>Heat-Strengthened (HS) glass is approximately two times stronger than annealed glass, but does not break into small fragments like safety glass. HS glass will generally not break spontaneously. The surface stress in HS glass must fall within narrow limits, specified by ASTM C1048 and related standards. Break pattern testing is no longer applicable (per ASTM C1048-97b), because the break pattern is very irregular and large. The GASP is the most reliable way to test HS glass for conformance to ASTM C1048.</td>
<td>Glass emerging from the annealing lehr of a float line generally has small residual surface stress. To assure good cutting properties, a glass slice can be tested using a polarimeter equipped with a Strainoptic MWA-100 Measuring Wedge mounted in our MISC-100 microscope. The surface stress can also be measured non-destructively using a GASP with a high sensitivity wedge.</td>
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**Safety Glass**

"Safety" glass is strong, plus it breaks into small fragments. The surface stress in Safety Glass is typically above 15,000 psi (100 MPa). Break pattern testing specifies the number of particles per unit area in a defined region, or the maximum weight of the largest collected fragments. This test is destructive and imprecise, and can result in substantial production loss if the results are not satisfactory. As with Fully Tempered glass, spontaneous breakage is known to develop in Safety Glass with even larger financial losses. To optimize furnace settings, assure conformance to specifications and avoid under- or over-stressing, Safety Glass should be frequently tested with the GASP.

**Bent and Laminated Glass**

In bent glass and in laminated automotive windshields, the surface stresses are higher than in annealed glass, and should be tightly controlled to detect undesirable surface tension areas caused by bending. GASP-CS is specially designed for these applications.

**TV Panels and Assemblies**

Heat-strengthened TV panels are stronger and safer than annealed panels. The GASP-CS equipped with a high sensitivity wedge is used in TV glass manufacturing for quality and process control of this key component. Modifications to the GASP-CS may be required for certain TV glass compositions.
Video-GASP

Strainoptic Technologies offers a monitor display system which is ideal for frequent users. The VIDEO-GASP system includes a GASP instrument equipped with a miniature CCD camera, video adapter head, and a black/white monitor for video viewing. Measurements are taken using the same procedure as the visual approach, but the monitor displays the fringe pattern. A Video Display Converter Kit is available for customers who already own a Strainoptic GASP — the regular GASP viewing optics can be removed by the customer and replaced with the Video Display Converter Kit.

Glass Specifications

GASP instruments are typically used for measuring stress on the tin side of soda-lime float glass with a refractive index of approximately 1.52. Customized prisms can be supplied for special glass types with other refractive indices. Special prisms are usually required for TV glass, borosilicate and other glass types.

Calibration and Certification

Each GASP instrument is factory calibrated. Occasional calibration can be accomplished using ASTM Standard Procedure C1377. A fixture is offered by Strainoptic.

Strainoptic Technologies also offers calibration or certification service. Complete documentation is included.

A GASP instrument can also be verified or self-certified with an optional CAL-PLATE. A CAL-PLATE is a glass plate that is measured with a calibrated GASP instrument. The surface stress measurement is identified and certified by Strainoptic.

Accessories and Spare Parts

A drop of index matching fluid is placed on the glass surface where the stress is measured with the GASP. Strainoptic supplies a one-ounce bottle of fluid with the equipment. Index fluid refills are available and can be ordered at any time.

The GASP is designed to measure the "tin side" of float glass. Strainoptic offers a selection of UV lamps which are useful for identifying the tin side.

GASP components such as Measuring Wedges, Laser Source Replacement Modules, Prism Sets, and other spare parts are available.

Glass Specifications

GASP-DIAS-1600 Automated System

The GASP-DIAS-1600 is a completely automated, PC-based surface stress measurement system. The image from the VIDEO-GASP is transmitted to a PC monitor. Strainoptic’s exclusive Digital Image Analysis System digitizes the monitor display of the GASP fringes, processes the information and automatically reports the surface stress. The system eliminates operator errors, offers greater measurement sensitivity and includes file storage capabilities for retrieval and tracking.
Operation Principle
The GASP is based on photoelastic test methods, using light rays traveling along the glass surface. The operation schematic is shown below. To use the GASP, the operator places a drop of index fluid (on the tin side for float glass) to assure optical contact. The GASP is placed on the fluid, sending a light beam through a prism at a critical angle $i_c$ along the surface.

The light follows the glass surface and emerges at a critical angle. The surface stress $S$ introduces a photoelastic retardation $R$ that increases linearly along the path 1-2. A quartz wedge (Babinet) compensator, containing a tight set of straight fringes, is placed on the path of the exit beam. The change in retardation, $\Delta R$, from 1 to 2, produces a tilt of the set of fringes at an angle $\alpha$, which is viewed through the GASP eyepiece. A crosshair also appears in the eyepiece, which is rotated by the operator to match the fringe angle. The angle of the crosshair is easily read by the operator and converted to a stress reading (psi, MPa). A calibration chart provides the surface stress measurement for each angle reading. The higher the angle, the higher the surface stress.

The stress is related to the measured angle $\alpha$ by:

$$\text{Stress} = S = \frac{\Delta R}{\Delta t_{12} C_B} = G \tan \alpha$$

where $C_B$ is the Material Stress (Brewster) Constant and $G$ is the GASP calibration constant.

The standard calibration chart is valid for soda lime float glass with the Material Stress Constant $C_B = 2.60$.

Strainoptic Products and Services
Strainoptic Technologies offers a full line of specialized instruments for glass quality control, ranging from handheld portable devices to PC-based automated instruments. Products include the GASP for measuring surface stress, GES-100 Edge Stress Meters, PS-100 Polarimeters, plus other specialized stress measurement instruments. Strainoptic Technologies also offers PC-based instruments for glass testing, suitable for inspecting float glass, automotive glass, optical products, and many other products. Ask for details.

Testing and Training Services
Surface stress, edge stress and other residual stress testing services are available from Strainoptic Technologies. All testing is conducted by a factory-trained engineer using equipment and test methods in accordance with ASTM standards.

Strainoptic also provides scheduled training programs on measuring residual stress. Technical support is available to assist you in solving difficult measuring problems.
Strainoptics®

Instruments for Measuring Residual Stress and Optical Distortion

Our exclusive GASP® Polarimeter measures surface stress non-destructively in heat-strengthened and tempered glass, per ASTM and other approved test methods. Models are available for flat or curved glass, and options include UV lights, calibration plates, and adapter kits for video/PC display.

Strainoptics’ PS-100 Polarimeters are modular systems, available in a variety of sizes and configurations, from general-purpose desktop models with plane and circular polarization to specialized instruments equipped with microscopes, measuring wedge assemblies, video-zoom cameras, high-intensity light sources, and large-field illuminators.

The VRP-100 Reflection Polarimeter System enables fast, accurate, and non-destructive measurement of residual stress in automotive windshields and other glass products containing black bands or painted areas. It is currently in use by many of the world’s leading automobile manufacturers and automotive glass fabricators. The VRP-100 permits accurate stress measurement without the need for removing paint. A reflective target allows clear areas of the glass to be measured.

The PES-100 Edge Stress Measurement System automates the off-line measurement of edge stress in automotive, as well as other glass applications. It uses Strainoptics’ patented, non-destructive stress measurement technology, combined with proprietary and user-friendly Windows-based software and a PC workstation, to provide fast, accurate and repeatable readings of residual stress required for QC of automotive glazing. Because the process is almost entirely automated, no special operator training or skills are required.

Strainoptics’ field-proven SCA-2004 Automatic Stress Scanners are custom-engineered for many quality control inspection applications to measure stress and/or birefringence. Systems are completely customizable, and can be configured to your hardware and software specifications, including special fixturing, manual or motorized product feed systems, special software features, file storage formats, and signal outputs. Simple, PC-based operation requires no special skills or knowledge; automatic measurement eliminates operator subjectivity.

The DIAS-1600 Stress Analyzer uses digital imaging technology for stress measurement applications. This PC-based system is used for quality control, process control, failure analysis, product development, and research to ensure that residual stresses remain within specified limits. This package is ideal for products in which very low stresses can hamper product performance, such as optical components, lenses, compact discs, annealed parts, glass seals, TV glass, etc.

The SCA-1500 On-Line Float Glass Stress Scanner automatically measures and reports residual stress across the glass ribbon at the cold end of the float line. It features user-friendly PC-based operation, and requires no special operator skills or training.

Strainoptics’ PSV-100 Portable Strain Viewer is a low-cost, battery-operated polariscope with a viewing area of 75 x 75 mm (3 x 3 inches). The product design offers an adjustable workspace, up to 180 mm (7 inches). The instrument is commonly used for evaluation of temper in glass, verification of annealing, and inspection of small plastic parts.

The SV-2000 Strain Viewer is a large-field polariscope suitable for inspection of nearly any size product, with a viewing area of 400 x 500 mm (16 x 20 inch). Quantitative measurements can also be obtained for many applications with an optional compensator. Available with plane or circular polarization.

The GES-100 Edge-Stress Meters are light, portable, battery-operated instruments that are specially designed to measure edge stress in annealed, heat-strengthened, and tempered glass. GES-100 Edge Stress Meters can be used on both flat and curved glass.

Instruments for Roller-Wave Distortion Measurement

Strainoptics offers several different models of our Series RWG “Flat-Bottom” or “3-point contact” gauges for measurement of roller-wave distortion in architectural glass, per test methods published by the Glass Association of North America (GANA) and ASTM.

NEW! Ask about our LiteWave™ Automated Roller-Wave Distortion Measurement System!