Tim’s top-tips!
Rheology Solutions for the Food Industries

Explanation and Evaluation of Cohesiveness, Cohesion Strength and Cohesive Quality
Company Profile

Rheology Solutions Pty Ltd is a specialist sales and service organisation dedicated to the science of materials characterisation and are the exclusive Australian distributor for the brand names HAAKE, NESLAB, PRISM and CAHN from Thermo Fisher Scientific, Optical Control Systems, Schleibinger Gerate and Marimex Industries Corporation range of equipment and instruments, and they also distribute the Shimadzu range of tensile testers and texture analysers.

Rheology Solutions recognises the importance of specialisation and dedication to a specific science and as such provides full technical support and service throughout Australia. The company goal is to integrate industry experience and materials characterisation techniques to provide practical solutions for customers.

Rheology Solutions has an established applications laboratory equipped with a comprehensive range of instruments to meet the requirements of material characterisation. Specialist contract testing services are also available and contracts can be tailored to suit discrete tests or protracted testing requirements involving a series of tests over a period of weeks or months.

A range of seminars and application specific workshops as well as product launches and demonstrations are provided throughout Australia. The seminars and workshops are designed to meet the needs of specific customer and industry applications. Rheology Solutions has its head office in Victoria and works with a team of specialist sales and factory trained service personnel throughout Australia. The combined experience of this team ensures that Rheology Solutions are able to provide their customers with access to the products to ensure that the right technical support and service is provided.

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Rheology Solutions Pty Ltd

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Tim’s Top Tips: Rheology Solutions for the Food Industries

Explanation and Evaluation of Cohesiveness, Cohesion Strength and Cohesive Quality

**Key Words:** Cohesiveness, cohesive quality, cohesion strength, rheology, rotational, universal tester, taste panel, solid, semi-solid, liquid, viscosity, yield stress, viscometer, rheometer, elastic & viscous moduli, force and displacement measurements.

**About The Author**

Tim has a background in engineering and specifically in rheology, with a B.Eng and Ph.D. in Chemical Engineering and has held postdoctoral research positions in engineering rheology. Tim’s research has continued for the last seven years and recent interests and publications include the application of rheology and rheometry to mineral, food, polymer and surface coatings systems. His current position encompasses the management of customer contract testing and also includes customer focused education and training. Additionally he is available to provide technical input for existing or proposed materials characterisation systems for both laboratory and production.

**Introduction**

Often the food industry must overcome problems related to (and often dominated by) the flow properties of their product, though the relationship between these properties and production related issues are not always immediately apparent. It is the purpose of this series of articles, "Rheology solutions for the food industries", to help illuminate the issues faced by the industry, how they relate to the flow properties of the problem materials and how they can be successfully measured and controlled with a view to better processing.

**Definitions**

Cohesiveness, cohesion strength and cohesive quality are interrelated properties, traditionally measured as a textural component of solid or semi-solid foods. In these terms they were defined by Szczeniak as being related to the extent of deformation and destruction of a product when a load is applied to it. As such, they have traditionally been measured using uniaxial testing machines (universal testers/texture analysers) or by taste panels. As the understanding of the interrelated nature of texture and microstructure of foods has improved, the science of flow and deformation (rheology) has been increasingly applied to the food industry, including for food related textural properties, such as cohesiveness. For foods, measurement of cohesiveness has come to apply to food (either semi-solid or solid) and elements of cohesiveness can be measured relative to the various physical properties of the food in deformation and flow. They can be measured in absolute or relative terms, depending on the technique chosen.

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Background and Discussion

Traditionally, cohesiveness has been measured either by using a taste panel or texture analyser, both of which give data of a relative and, in the case of taste panels, subjective nature. Sophisticated and sensitive measurement techniques and equipment now allow much of this work to be done using scientific instruments. Additionally, newer generation rheometers and viscometers can allow the direct measurement of fundamental physical properties of the materials, to help the food scientist to judge these important textural properties, as well as for use in proper equipment design and sizing. In the case of the relationship between cohesiveness and liquid (and semi-solid) flow properties, the important variables may include some, or all of extensional viscosity, the elastic and viscous moduli, the complex viscosity, shear viscosity, thixotropy etc.

Cohesiveness analysis using uniaxial compression or extension – solid and semi-solid materials

The efficiency and suitability of instrumentation for cohesiveness related testing for solid and semi-solid materials using uniaxial compression or extension is related to the geometry of the probe and to the textural characteristic. In general, uniaxial testing machines are used for this purpose and the tests involve forcing the probe downwards, compressing the foodstuff and measuring the force required to do so.

Potential problems with these measurements include:

- Which is the correct sensor?
  There is a large variety of different sensors. This is not itself a problem, and may in fact help to solve problems, but care must be taken that the most appropriate one is chosen for the job. For cohesiveness testing, the most commonly used sensor for uniaxial testing is a flat disc. The disc should be of greater diameter than the material at all times during the test, and the load cell should be zeroed with the sensor attached, but before the test begins.
- Repeatability:
  A relatively large number of tests are often necessary (sometimes as many as 20 per material) in order that a statistically relevant measurement is made. This is particularly true of semi-solid materials eg thick pastes. The number of tests is often high relative to those required on a rheometer (often as few as 3-5 tests), for example, but the time and expense is usually lower than that associated with taste panels. This repeatability issue is often not related to the measurement or the instrument, more often to inconsistent sample preparation or to the heterogeneous nature of many food products. In the cases where the repeatability is related to the measurement, then a change in conditions, such as increasing or decreasing the speed of the cross-head, or reviewing the suitability of a particular load cell or sensor may be necessary. Often, the same load cell can not be used to measure all of the products a company manufactures (eg peanut butter, and/or for a dairy company, yoghurt, spreadable cheese and hard (eg cheddar) cheese may all require different load cells so that the best data can be gathered.

- Which is the best test method?
  Many operators have decided upon test methods which they see as the most relevant for their products, care should be taken that these tests truly represent the desired property. Szczeniak at General Foods in the USA, standardised many of these tests, specifically with a view to this type of testing. The three related measurements and defined cohesiveness, and related properties, often to inconsistent sample preparation or to the heterogeneous nature of many food products. In the cases where the repeatability is related to the measurement, then a change in conditions, such as increasing or decreasing the speed of the cross-head, or reviewing the suitability of a particular load cell or sensor may be necessary. Often, the same load cell can not be used to measure all of the products a company manufactures (eg peanut butter, and/or for a dairy company, yoghurt, spreadable cheese and hard (eg cheddar) cheese may all require different load cells so that the best data can be gathered.

- The tests are, in general, relative:
  The complexity of the flow field during the displacement, and the heterogeneity of the test material means that the dissipation of the forces through the materials is difficult to fully predict. As a result, it is often not possible to collect absolute data. On the other hand, relative data is usually sufficient for many applications.

- Control of the compression/extension of the sample:
  Many samples fracture under quite low loads, and it is often necessary to refine the test technique.

- Poor mimicking of mastication:
  Clearly, mastication takes place in several directions and with varying force as we sense different textures in the food in our mouth. Standardising test techniques, (by always using the same force and/or strain (displacement) parameters for each test and choosing a test which best represents the element(s) of mouthfeel which are important to your consumer) at least permit the same properties to be measured, though the difficulties with mimicking the complexity of the mouth have not been overcome.

- Stiff materials can be difficult to measure:
  Solid materials can cause problems during measurements because of their high rigidity. Though this is not often the case with food materials since the mouth would be damaged if too-stiff materials were chewed, instrumentation itself can help avoid this potentially painful outcome. For highly rigid materials, the measuring equipment itself should be highly rigid, so that the instrument or sensor do not deform before the sample does. Judicious choice of instrument and the load cell (measuring range, accuracy etc), suited to stiff materials is necessary at the instrument specification stage.

- Szczeniak texture analysis for calculating Cohesiveness, cohesion strength and cohesive quality

  Cohesiveness (A3) is the force required to move food which has bonded to the mouth or hands during chewing, cohesion strength (C) is the force with which a material resists a vertical upward movement after it has been initially compressed. The cohesive quality (A2/A1) is the ratio of the deformation and destruction of a material after it has been subjected to each of two consecutive load and release cycles.

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Cohesiveness analysis using rotational viscometers and rheometers – liquids

Liquid and semi-solid testing using rotational viscometers and rheometers requires small sample volumes. In the case of a laboratory viscometer or rheometer, the material is placed in a gap between a holding cup or a flat plate and a cylindrical, conical or flat plate sensor. The sensor moves (rotates or oscillates), resulting in a measured force and displacement of the sensor and sample. The force and displacement are used to measure the flow properties of the material. These flow properties – yield stress, shear viscosity, and viscoelastic properties – can be related to some of the textural properties of liquid or semi-solid foods.

Potential issues surrounding these types of tests may include:

- **Relative vs absolute data:**

Some of the early model instruments, for example those meeting the 'Brookfield' standard, ISO2555, for testing provide the user with relative data for most materials, because the gap between the holding cup and the rotating sensor is large. In contrast, most modern viscometers can provide absolute data because the measuring gap is small and the sensor geometry is fully defined.

- **Poor mimicking of mastication:**

As in the case of uniaxial testers, the types of movement in the human mouth are much more complicated than that generated by a rotational instrument. However it has been shown that, by using standard tests, the rheological quantities measured using these instruments can be related to the experience of the consumer during mastication.
• **Shear properties difficult to comprehend:**
  A critical shear property related particularly to cohesiveness and cohesive strength is the yield stress. This is the minimum force required to initiate movement in a material.

  The vane sensor system: Vanes can be different sizes to detect different ranges of yield stresses

  The yield stress can be simply measured using the vane technique with a Controlled Rate (CR) viscometer or a Controlled Stress (CS) rheometer for virgin materials and using either the vane, or other serrated sensor and controlled stress ramp on a CS rheometer for a presheared material. Another critical shear property is the shear viscosity; this material property measures the resistance of the material to flow after large scale deformation (e.g., chewing) continued interparticle cohesion increases the shear viscosity of the material.

  Flow and viscosity curves for food paste, the viscosity is not constant and the material exhibits a yield stress zero deformation until the yield stress of 18 Pa approx. has been exceeded

  The vane sensor system: Vanes can be different sizes to detect different ranges of yield stresses

• **Viscoelastic properties not repeatable:**
  Viscoelastic properties are generally measured by means of a frequency sweep (oscillating a sensor at different rates in the sample) in the Linear Viscoelastic Envelope (LVE). In the LVE, properties are independent of the amplitude or force applied during oscillatory measurements.

• **Structural disruption on loading:**
  Many foods, in particular semi-solids, but also liquids are made up of delicate biological scaffolds. These can be disrupted by shear stresses, for example by stirring, or by closing the measuring geometry of a viscometer or rheometer. This problem can often be overcome by allowing the material to rest afterwards, so that the structure rebuilds. In cases where the structure does not recover, then the degradation can at least be made repeatable by using computer controlled geometry closure, rather than manual. Another often used solution is to preshear the material to a state of equilibrium, so that the structure has always been destroyed to the same level before the commencement of each test. This technique has the obvious disadvantage that the material is no longer identical to that first experienced by the consumer, but is similar that remaining in the mouth after some chewing has taken place. In the case of yield point measurement with the vane technique, the material can be tested in a condition identical to that which it is received by the consumer, as the material can often be tested in the packaging with minimal interference to the structure of the food.
Measurements not carried out in the LVE are not repeatable, and are probably not comparable for different materials.

- **Viscoelastic properties difficult to understand:**

Viscoelastic flow properties tell us about the undisturbed (in the LVE) structure of the material.

In general the properties measured are the viscous and elastic moduli and the complex viscosity. The complex viscosity is a measure of the resistance of the material to flow and the comments made for shear viscosity are valid here also. Higher viscosity materials will require higher forces to initiate and continue flow. At low frequencies, for polymeric systems (starch, guar, xanthan, carageenan gums etc), the viscoelastic moduli show the contribution of high molecular weight (MW) species, the crossover point of the moduli shows the point at which the moduli are equal and is often used as a quality control point for materials. Changes in the magnitude of the moduli at the crossover point imply changes in molecular weight distribution, and changes in the frequency at which the crossover point occurs implies a change in the mean MW of the system. Some practical and theoretical training can often help nervous operators overcome the perceived complexity of viscoelastic measurements and assessing the data.

**Cohesiveness analysis using a taste panel – all edible foodstuffs**

Taste panels are the ultimate approval mechanism for foods, no machine can perfectly imitate the complexities of simultaneously chewing, smelling and tasting.

Testing for cohesiveness, cohesive quality and cohesive strength using a taste panel is achieved using a group of people representative of the general population of interest to the product manufacturers. These panellists may be trained, in which case, fewer of them are generally required since terminology and scoring for the potentially confusing nomenclature of texture analysis is simplified when the participants fully understand it. If the panellists are not trained, the numbers required are usually greater, and the time required to collect the relevant data is also greater. This technique, however has the advantage that it is being carried out by humans, and therefore the complexities of tasting, chewing and swallowing are all accounted for. Both solid and liquid foods can be tested. Cohesiveness can be assessed by a taste panel by first pushing the material onto the roof of the mouth and then estimating the force required to move it. Cohesion strength can be assessed by the relative difficulty in separating two fingers with a flattened portion of the material between them, or to remove the tongue from the roof of the mouth after an initial compression. Cohesive quality can be assessed by comparing the relative difficulties and associated with two successive compressions to approximately the same final state of a material.
Potential problems may include:

- **Panellist condition:**
  The events, culinary or otherwise, of the preceding few days, hours or minutes may have an unknown influence on the panellist’s impression of the food which they are testing. This can make it difficult for the panellists to agree on their impressions.

- **Time and expense:**
  Large numbers of people and large amounts of time are necessary for these types of tests. Large numbers can often be reduced by training the panel before the testing begins.

- **Reproducibility:**
  Individuals can be highly subjective, and reproducibility may be an issue. Different demographics may also react differently to the same material. Different taste panels can be convened to cater for different target markets. Good panel training and understanding of the different definitions can help to overcome this issue.

- **The measurements are not absolute:**
  Therefore it is difficult to compare results from different foodstuffs or from different panels. Materials with different tastes and odours can be experienced quite differently by panellists even though they have similar structural properties. Good panel training and understanding of the different definitions can help to overcome this issue.

- **The influence of taste, odour etc:**
  Taste and odour can have an effect on the perception of texture, and it may be difficult for panellists to separate these effects. The best solution is to train the panel well, and if possible to use instrumental techniques to check panel data. Materials with different tastes and odours can be experienced quite differently by panellists even though they have similar structural properties. Good panel training and understanding of the different definitions can help to overcome this issue.
Summary

Table 1 summarises the possibilities for measuring cohesive properties using the techniques discussed. Each of the techniques is ranked between 0 and 5 for each of the potential issues and solutions, where:

5=Excellent  4=Good  3=Adequate  2=Possible  1=Difficult  0=Not Possible

Determining the most suitable type of instrument is not simply a matter of adding up the ranking for each. Rather, identify which measurement technique, variable etc is most relevant and appropriate for your application/product. Often, more than one technique is required to ensure consistency, reproducibility and accuracy is achieved.

More and more food companies are now including texture analysis and rheology to support, supplement and further direct their R&D and recipe modifications.

Table 1: Assessment of strengths/weaknesses for each technique

<table>
<thead>
<tr>
<th>Technique:</th>
<th>Uniaxial Force Measurements</th>
<th>CR Viscometers</th>
<th>CS Rheometers</th>
<th>Taste Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solids</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Semi-solids</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Liquids</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Sensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large variety</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Direct taste/odour detection*</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Rigid samples easily measured</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Structural disruption on loading avoidable</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Test Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute*</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Relative*</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Quickly varied</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Widely varied</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Objective measurements</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Subjective assessments*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Tests inedible materials</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
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<tr>
<td>Rapid test completion</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
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<tr>
<td>Primary Variable Parameter</td>
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<tr>
<td>Load/Force</td>
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<td>0</td>
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<td>1</td>
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<tr>
<td>Displacement</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Number of Participants</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>High*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Low*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Single operator</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intuitively comprehended</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

* Depending on the test, these parameters may be viewed alternatively as either a strength or as a weakness.
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Other Notes Available in the Tim’s Top Tips - Rheology Solutions for the Food Industries Series are:

- Explanation and Evaluation of Mouthfeel (Rheo253)
- Explanation and Evaluation of Shelf life (Rheo254)
- Explanation and Evaluation of Processability (Rheo255)

Other Information Available for the Food Industries include:

- Rheology Solutions for Food Industries Information Kit
- Applications Laboratory and Contract Testing Capabilities Statement for Food Industries
- Technical Literature for Food Industries

Focused on providing our customers with materials characterisation solutions through knowledge, experience and support.

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# Food Dictionary

<table>
<thead>
<tr>
<th>Industry Term</th>
<th>Definition</th>
<th>Governing Properties</th>
<th>Rheology Solutions Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute</strong></td>
<td>Data which can be compared with another reading collected using a viscometric geometry (parallel plate, cone and plate, concentric cylinder). Absolute data is expressed in scientific units.</td>
<td>N/A</td>
<td>HAAKE ViscoTester, VT550, HAAKE RheoStress, HAAKE MARS, HAAKE PolyLab.</td>
</tr>
<tr>
<td><strong>Cohesiveness</strong></td>
<td>The extent of deformation and destruction of a product when a load is applied to it. This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.</td>
<td></td>
<td>Shimadzu EZ Test.</td>
</tr>
<tr>
<td><strong>Complex Viscosity</strong></td>
<td>The viscosity measured by dynamic rheometry, related to both the viscous and elastic portions of flow for a viscoelastic fluid.</td>
<td></td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
<tr>
<td><strong>Controlled Stress (CS) Ramp</strong></td>
<td>A technique for testing materials. The shear stress is gradually increased, rather changed in a stepwise fashion.</td>
<td>The capabilities of the rheometer will define its ability to conduct a CS ramp.</td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
<tr>
<td><strong>Crossover Point</strong></td>
<td>The point at which the viscous modulus is quantitatively equal in to the elastic modulus. This is a property governed by the viscoelastic properties of the material - elastic and viscous moduli (G’ and G’”). It is measured on a CS rheometer using a frequency sweep.</td>
<td></td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
<tr>
<td><strong>Elastic and Viscous Moduli</strong></td>
<td>Many liquids have a solid-like (elastic) component and a liquid-like (viscous) component. The elastic and viscous moduli, G’ and G” respectively, are measures of the contribution of these two to the deformation of the liquid.</td>
<td></td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
<tr>
<td>Industry Term:</td>
<td>Definition:</td>
<td></td>
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<td>----------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Extensional Viscosity</strong></td>
<td>The extensional viscosity of a liquid is the resistance to flow of the liquid as it is being stretched. This is a different property to (and independent of) either the shear viscosity or the complex viscosity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>The extensional viscosity depends on the temperature, the rate of deformation of the liquid. It can be measured on an extensional viscometer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>HAAKE CaBER.</td>
<td></td>
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<table>
<thead>
<tr>
<th>Industry Term:</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition:</td>
<td>Measure of the ability of a sample to be moved (by gravity or other force).</td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>The rate of flow of a liquid is governed by its properties in shear, including the yield point at low shear, measured with a CR viscometer, and by the viscoelastic properties of the liquid, as measured on a frequency sweep by a CS rheometer. CR measurements can often be made in-line.</td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS, Marimex ViscoScope.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Term:</th>
<th>Frequency Sweep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition:</td>
<td>This technique is an analysis of the dependency of the rate dependent viscoelastic properties; it is usually carried out in the LVE of the test material.</td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>N/A</td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Industry Term:</th>
<th>Linear Viscoelastic Envelope (LVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition:</td>
<td>The LVE is the region in which the internal structure of a material remains unchanged as the imposed stress or deformation is gradually increased.</td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>Measured on a CS rheometer using a stress sweep or a strain sweep.</td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Term:</th>
<th>Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition:</td>
<td>Data which can be compared with another reading collected under identical test conditions. Units are not scientific and the instrument and conditions also need to be specified with the data.</td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>N/A</td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>PRISM EuroLab, HAAKE VT01/02, HAAKE VT6/7, HAAKE PolyLab, Marimex ViscoScope.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Term:</th>
<th>Rheometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition:</td>
<td>An instrument designed for the measurement of viscous and viscoelastic flow properties at specified temperature and atmospheric conditions, by measuring the force required to move one layer over another without turbulence.</td>
</tr>
<tr>
<td>Governing Properties:</td>
<td>Rheometers often have air bearings, making them highly sensitive to small variations in load or displacement and can operate in rotation or oscillation for Controlled Rate or Controlled Stress modes. Some rheometers have mechanical bearings, but in general they do not have the required sensitivity to make good use of CS mode in these cases and can not run oscillatory measurements well (or at all).</td>
</tr>
<tr>
<td>Rheology Solutions Instrument:</td>
<td>HAAKE RheoStress, HAAKE MARS.</td>
</tr>
</tbody>
</table>
**Industry Term:** Shear Stress  
**Definition:** This is the force per unit area imposed on an element of fluid.  
**Governing Properties:** The shear stress is dependent on the geometry of the fluid element and can be measured by a CR viscometer and may be imposed by a CS rheometer.  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

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**Industry Term:** Shear Viscosity  
**Definition:** The shear viscosity is the resistance of a fluid to flow when a shear stress is exerted upon it.  
**Governing Properties:** Shear viscosity depends on temperature and usually shear rate or shear stress. It can be measured on a viscometer or a rheometer, using viscometric measuring geometries.  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress.

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**Industry Term:** Strain  
**Definition:** The displacement of an element of material as a result of an applied force.  
**Governing Properties:** N/A  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RheoStress, HAAKE MARS.

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**Industry Term:** Thixotropy  
**Definition:** Thixotropic fluids show shear thinning behaviour combined with a time dependency. The viscosity of a thixotropic fluid drops when subjected to a constant shear rate for a period of time. The viscosity of thixotropic fluids often recovers substantially over a period of time after the shearing forces have been removed.  
**Governing Properties:** Thixotropy depends on the rate of structural recovery in the material. It can be measured using a flow curve on a CR or CS instrument, or by measuring the recovery of the moduli after shearing on a CS rheometer.  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

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**Industry Term:** Viscoelastic Properties  
**Definition:** These are properties of the material at rest. See ‘Complex Viscosity’, ‘Elastic and Viscous Moduli’, ‘Crossover Point’.  
**Governing Properties:** Governed by the structural properties of the material at rest, measured on a CS rheometer.  
**Rheology Solutions Instrument:** HAAKE RheoStress, HAAKE MARS.

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**Industry Term:** Viscometer  
**Definition:** An instrument for measuring the viscosity of a liquid at specified temperature and atmospheric conditions, by measuring the force required to move one layer over another without turbulence; also referred to as viscometer.  
**Governing Properties:** Viscometers usually have mechanical bearings in their motor and generally operate in rotational mode only.  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RotoVisco.

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**Industry Term:** Yield Stress  
**Definition:** The minimum shear stress required to initiate flow in a fluid.  
**Governing Properties:** Governed by the structural properties of the material at rest, measured by extrapolation using a flow curve, or using the vane technique, both on a CR or CS instrument. It can also be measured using a CS rheometer by a stress ramp.  
**Rheology Solutions Instrument:** HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.
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Tim’s Top Tips – Rheology Solutions for the Food Industries

Explanation and Evaluation of Cohesiveness, Cohesion Strength, and Cohesive Quality

To ensure a speedy response to your enquiry, please take the time to ensure you complete accurately all the relevant sections below.

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- HAAKE VT550 – Controlled Rate Viscometer
- HAAKE RotoVisco 1 - Controlled Rate Viscometer
- HAAKE ViscoTester VT6 Plus / VT7 Plus – QA Viscometer
- Contract Testing
- Technical Literature (Please specify)

HAAKE RheoStress RS600 – Controlled Stress Rheometer
HAAKE CaBER 1 – Extensional Rheometer
HAAKE MARS - Modular R&D Controlled Stress Rheometer
Rheology Solutions for Food Industries Kit
Training & Seminars
Other (Please specify)

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