The online scanning measurement of silicone basis weight on release paper has been a great challenge as the coating basis weight is typically only in the range from 0.5 to 3 g/m² (0.3 to 2 lbs/ream).

Until recently, online sensors for silicone measurement have not been reliably accurate, or have required prohibitively high levels of on-site technical support.

A new sensor developed in 2013 employs a high-resolution grating spectrometer in the near infrared spectrum to measure silicone coatings down to 0.25 g/m² (0.15 lbs/ream) as part of an industrial scanning web gauging system.

This new sensor does not require any intensive maintenance or specialized on-site expertise.
InfraScope Si
Spectrometer Silicone Coating Weight Sensor

- Historical Online Silicone Coating Measurement Attempts
- InfraScope Operating Principal
- Design Details
- Lab Test Results
- Field Test Results
- Specifications
- System Configuration
Throughout the past 30+ years, numerous methods of measuring a thin silicone release layer online directly on the coating line have been attempted:

- Total Mass Subtraction, typically with a beta transmission sensor
- Laboratory-Style FTIR Spectrometers
- Filter Wheel IR Sensors
- X-Ray Fluorescence Sensors
InfraScope Si
Spectrometer Silicone Coating Weight Sensor

HISTORICAL ONLINE SILICONE RELEASE COATING MEASUREMENT ATTEMPTS

Total Mass Subtraction

- The total mass subtraction method uses two basis weight measurement devices, such as beta transmission or IR filter wheel sensors, to measure the total web mass before and after the silicone coater.

- Data is coordinated from each scanner to provide a “same spot” subtracted measurement of just the silicone coating.

- Due to the very light silicone coating weight compared to the paper or polymer substrate, this total mass subtraction method requires an unrealistically high measurement repeatability from each sensor in order to obtain a useful subtracted net silicone measurement (RSS error is large compared with silicone coating).

- Few, if any, successful installations.
Laboratory FTIR Spectrometers

- FTIR spectrometers designed for laboratory use mounted onto scanning frames for online use
- Benchtop instruments are stable in a lab environment, but were never designed for the vibration, temperature extremes and continuous use requirements of a factory environment
- Field calibration techniques were never satisfactorily developed and required PhD-level support
- This technique has been abandoned.
Filter wheel IR sensors

- The broad spectral resolution of the filter wheel systems (50 – 70nm) makes it very difficult to separate the silicone absorption from the overlapping absorption of the base.
- Compositional changes of the paper due to grade changes or recycled content create continuous calibration shifts and measurement “noise”.
- Usefulness continues to be questioned by silicone coating manufacturers.

![Graph showing absorption against wavelength](image)
InfraScope Si
Spectrometer Silicone Coating Weight Sensor

HISTORICAL ONLINE SILICONE RELEASE COATING MEASUREMENT ATTEMPTS

X-Ray Fluorescence (XRF) Instruments

- XRF technique infers the amount of silicone in the target by measuring the amount of elemental Silicon in the coated paper sample
- There is also a significant amount of Silicon in the substrate paper which must be subtracted from the silicone coated paper measurement
- Different grades, different paper suppliers, and a variable amount of recycled content in the paper will cause continuous calibration drift
- Online XRF instruments no longer available
**InfraScope Si**

Spectrometer Silicone Coating Weight Sensor

**Features:**
- Designed from the ground up as an ONLINE scanning instrument
- Industrially rugged and reliable
- Extremely selective measurement with 1nm spectral resolution
- Very low measurement noise
- 1ms sampling rate
- Measures down to 0.25 g/m² with 0.01g/m² resolution
- Easy to calibrate
  - Reduced sensitivity to paper
- Non-Nuclear
- Single-Sided measurement
How it Works:

- The sample is illuminated with a stable source of broad spectrum infrared light (1–2.2 µm).
- The NIR Spectrometer scans the infrared spectrum with a resolution of 1 nanometer (nm).
Spectral analysis is automatically performed to provide very high resolution absorption peaks for the measurement of silicone.

Sample calibration is easy as the silicone absorption spectrum is well known and distinct from substrates and adhesives.
**InfraScope Si**

Spectrometer Silicone Coating Weight Sensor

Specific C-H bonds measured in the silicone compound

1703 nm  CH₃ Group Vibration
1746 nm  CH₃ Group Vibration
1760 nm  C-H Methyl Group Vibration

```
H₂C=CH - Si - O - (Si - O)ₙ - (Si - O)ₘ - Si - CH=CH₂
   |       |       |       |       |
  Me     Me     Me     Me
```

Diagram showing absorption peaks at 1703, 1746, and 1760 nm with corresponding vibrations.
InfraScope Si
Different Basis Weights (A-F) of Silicone Release Coating

Absorption vs. Wellenlänge [nm]

- A
- B
- C
- D
- E
- F
- Wacker

1000 1200 1400 1600 1800 2000 2200
InfraScope Si
Calibration

- Calibration and spectral analysis tools are built into the control and display station
- Since the IR absorption spectrum of pure silicone is known, the system can be pre-linearized before it is installed on the silicone coating line
Laboratory Test Results:

- The test setup in the lab included the Infrascope Spectrometer sensor with a ceramic reflector 30mm from the sensor face.
- Lab tests were performed on 9 different paper qualities (three different base papers coated with three different amounts of silicone).
- 20 samples of each paper quality were provided.
- Samples of various basis weights of silicone coating on three different paper substrates were cut into precise 100 cm² area samples which were subsequently measured with a laboratory XRF and then weighed.
InfraScope Si Lab Results

Laboratory Test Results:

The InfraScope data were compared to tests of the same samples using a laboratory X-Ray Fluorescence sensor (XRF) which is summarized below:

<table>
<thead>
<tr>
<th>Paper</th>
<th>Lab value XRF (lb/3000ft²)</th>
<th>InfraScope (Average of 20 Sheets) (lb/3000ft²)</th>
<th>standard deviation (lb/3000ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1964-3</td>
<td>0.860</td>
<td>0.873</td>
<td>0.032</td>
</tr>
<tr>
<td>T1964-2</td>
<td>1.047</td>
<td>1.022</td>
<td>0.019</td>
</tr>
<tr>
<td>T1964-1</td>
<td>1.175</td>
<td>1.187</td>
<td>0.028</td>
</tr>
<tr>
<td>T1965-3</td>
<td>0.990</td>
<td>0.992</td>
<td>0.006</td>
</tr>
<tr>
<td>T1965-2</td>
<td>1.077</td>
<td>1.074</td>
<td>0.007</td>
</tr>
<tr>
<td>T1965-1</td>
<td>1.157</td>
<td>1.159</td>
<td>0.012</td>
</tr>
<tr>
<td>T1972-3</td>
<td>0.802</td>
<td>0.797</td>
<td>0.030</td>
</tr>
<tr>
<td>T1972-2</td>
<td>0.957</td>
<td>0.969</td>
<td>0.021</td>
</tr>
<tr>
<td>T1972-1</td>
<td>1.130</td>
<td>1.124</td>
<td>0.033</td>
</tr>
</tbody>
</table>
InfraScope Si
Field Testing

- The InfraScope was installed on one of Green Bay Packaging's coating lines in Green Bay Wisconsin, where silicone release coating is applied to paper substrates.
- Silicone basis weight targets range from 0.7 to 1.2 lbs/ream (1.1 – 2.0 gsm)
- Calibrations were verified compared to laboratory XRF for two weeks, and then data was acquired for an additional 580 rolls
InfraScope Si Field Results

GBP Laboratory XRF versus Mahlo InfraScope
Silicone Release-Coated Papers, 4Q2015

Pounds per 3000 ft² Ream of Silicone

Roll #

Calibration Runs  Roll Label  Layflat

XRF Lab Data  Mahlo InfraScope Data
InfraScope Si Field Results

Roll Label Product

GBP Laboratory XRF versus Mahlo InfraScope - Roll Label
4Q2015
- Detail -
InfraScope Si Field Results

Layflat Product

GBP Laboratory XRF versus Mahlo InfraScope - Layflat
4Q2015
- Detail -

Pounds per 3000 ft² Ream of Silicone

Layflat Roll #
# InfraScope Si
Spectrometer Silicone Coating Weight Sensor

## Specifications

<table>
<thead>
<tr>
<th>Sensor</th>
<th>INFRASCOPE NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement principle</td>
<td>Absorption of infrared energy</td>
</tr>
<tr>
<td>Spectral range</td>
<td>1000 nm – 2170 nm</td>
</tr>
<tr>
<td>Measurement Range</td>
<td>Silicone: 0.25 g/m² – 150 g/m² Additional ranges upon request</td>
</tr>
<tr>
<td>Measurement Accuracy</td>
<td>0.03 g/m²</td>
</tr>
<tr>
<td>Measurement Spot Size</td>
<td>25 mm</td>
</tr>
<tr>
<td>Measurement Gap</td>
<td>10, 15, 30 mm</td>
</tr>
<tr>
<td>Measurement Mode</td>
<td>Reflection Mode</td>
</tr>
<tr>
<td>Power Supply</td>
<td>24 V DC</td>
</tr>
<tr>
<td>Max. ambient temperature</td>
<td>60 °C without additional cooling</td>
</tr>
</tbody>
</table>
Uniscan
Single-Sided Scanning Frame

- Large, Steel Reinforced Urethane Drive Belt
- Brushless High-Torque AC Motor
- Dynamically Sealed
- Easy Access for Maintenance
InfraScope Si
Mounted Online on Uniscan Frame
InfraScope Si
Full Online Web Gauging System
In-House Demo / Pilot Facility
Spartanburg, SC
Thank you!

Eric J. Reber
Mahlo America, Inc.