Section Half Multisensor Logger (SHMSL): User Guide

Manual Information

<table>
<thead>
<tr>
<th>Topic</th>
<th>See page...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>Apparatus, Reagents, &amp; Materials</td>
<td></td>
</tr>
<tr>
<td>Setting up the Instrument Sensors</td>
<td></td>
</tr>
<tr>
<td>Setting Measurement Parameters</td>
<td></td>
</tr>
<tr>
<td>Running Samples</td>
<td></td>
</tr>
<tr>
<td>Quality Assurance/Quality Control</td>
<td></td>
</tr>
<tr>
<td>LIMS Integration</td>
<td></td>
</tr>
<tr>
<td>Health, Safety, &amp; Environment</td>
<td></td>
</tr>
<tr>
<td>Maintenance/Troubleshooting</td>
<td></td>
</tr>
</tbody>
</table>

Introduction

The Section Half Multisensor Core Logger succeeds the Archive-Half Multisensor Track (AMST) in the physical properties laboratory. The SHMSL simultaneously measures spectral reflectance and magnetic susceptibility on core section halves. Data generated from these sensors are used to augment the core descriptions.

Reflectance Spectrometry

–Percent reflectance plotted against depth supports lithology descriptions.
Munsell color can theoretically be derived or confirmed from reflectance data.
Color parameters can provide a detailed time series of relative changes in the composition of the core material and can be used to correlate sections from core to core or hole to hole and to analyze cyclicity of lithologic changes.
Spectral data can be used to estimate the abundances of certain compounds.
- Visible range provides semiquantitative estimates of hematite and goethite with better sensitivity than XRD.
- Near-infrared or near-ultraviolet ranges allow estimates of carbonate, opal, organic matter, chlorite, and some combinations of clay minerals.

Magnetic Susceptibility
Can be used to confirm whole-round core section magnetic susceptibility measurements (the SHMSL can measure magnetic susceptibility at a similar sampling point spacing to the whole-round measurements, or the user can select a completely different frequency of analysis)
MS data is used for correlation with other age-depth proxy measurements.

Theory of Operation
A split and scraped core section in a half-core liner is placed on the core track, where an integral barcode reader records the sample number and imports sample information from the LIMS. The electronics platform moves along a track above the core section, recording the sample height in the core liner using a laser sensor. The laser establishes the location of bottom of the section, then the platform reverses the direction of movement, moving from bottom to top while recording point magnetic susceptibility and spectral reflectance data at user-specified data acquisition intervals (generally 2–10 cm).

Reflectance Spectrometry
- Measured from 380 to 900 nm at 2 nm intervals using a halogen light source, covering a wavelength range from through the visible spectrum and slightly into the infrared domain.
- Scanning the entire wavelength range takes ~5 s per data acquisition offset.
- Data are generated using the CIELAB L* a* b* color system:
  - L* represents lightness, where 0 yields black and 100 indicates diffuse white;
  - a* represents magenta to green tinting, where negative numbers indicate red/magenta shading and positive numbers indicate green shading; and
  - b* represents yellow to blue tinting, where negative numbers indicate yellow shading and positive number indicate blue shading.
- Data are also stored and returned as CIELAB Tristimulus XYZ values. The definition of X, Y, and Z is complex and the reader should refer to reference materials for an explanation.[DH1]

Magnetic Susceptibility
- Measured at the same data acquisition rate as spectral reflectance using a contact probe with a flat 15 mm diameter sensor.
- The sensor can be configured for different integration times (1 Hz or 0.1 Hz) and different numbers of replicate measurements. Our standard conditions are 3 measurements at 1 Hz measurement frequency for each offset. These three results are averaged and uploaded to the database. Thermal drift is effectively eliminated by zeroing the meter before each section.
- Data are reported in dimensionless instrument units. In order to use these data as SI magnetic susceptibility units, the appropriate volume correction must be applied, which varies by sensor type.
Apparatus, Reagents, & Materials

Hardware

The SHMSL system consists of the following hardware components (Figure 1):

- Ocean Optics USB4000 visible spectrum spectrophotometer
- Bartington MS2E or MS2K magnetic susceptibility contact probe
- Integrating sphere
- Laser
- Barcode reader
- Instrument platform
- Hardware abort switch

Bartington MS2F Probe Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (mm)</td>
<td>Length = 85</td>
</tr>
<tr>
<td></td>
<td>Tip diameter = 15</td>
</tr>
<tr>
<td></td>
<td>Tip to shoulder = 20</td>
</tr>
<tr>
<td>Operating frequency (kHz)</td>
<td>0.580</td>
</tr>
<tr>
<td>Maximum resolution</td>
<td>$2 \times 10^{-7}$ CGS [DJH to Author: we should express this (and all further references in the document in SI, not cgs if possible)]</td>
</tr>
</tbody>
</table>

Figure 1. SHMSL Hardware.
Accuracy (%)  

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature induced drift</td>
<td>$2 \times 10^{-6}$ CGS/°C</td>
</tr>
<tr>
<td>Spatial resolution (mm)</td>
<td>20</td>
</tr>
<tr>
<td>Calibration (tip contact)</td>
<td>$k \times 0.5$ (H$_2$O)</td>
</tr>
</tbody>
</table>

**Bartington MS2F Probe Susceptibility Meter**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (mm)</td>
<td>241 × 158 × 50</td>
</tr>
<tr>
<td>Operating temperature range (°C)</td>
<td>–10 to +40</td>
</tr>
<tr>
<td>Linearity</td>
<td>1% to 9999</td>
</tr>
</tbody>
</table>

**Ocean Optics USB4000 Miniature Fiber Optic Spectrometer/CCD Detector**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (mm)</td>
<td>89.1 × 63.3 × 34.4</td>
</tr>
<tr>
<td>Detector</td>
<td>3648 element linear Si CCD array</td>
</tr>
<tr>
<td>Detector range (nm)</td>
<td>200–1100</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>&lt;0.05% @ 600 nm</td>
</tr>
<tr>
<td></td>
<td>&lt;0.01% @ 435 nm</td>
</tr>
<tr>
<td>Corrected linearity (%)</td>
<td>&gt;99.8</td>
</tr>
<tr>
<td>Pixel size (µm)</td>
<td>8 × 200</td>
</tr>
<tr>
<td>Signal to noise ratio</td>
<td>300:1 at full signal</td>
</tr>
</tbody>
</table>

**Ocean Optics HL-2000 Halogen Light Source with Attenuator and TTL-Shutter**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (mm)</td>
<td>58 × 59 × 140</td>
</tr>
<tr>
<td>Wavelength range (nm)</td>
<td>360–1700</td>
</tr>
<tr>
<td>Stability (%)</td>
<td>0.5</td>
</tr>
<tr>
<td>Drift (%/h)</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Bulb life (h)</td>
<td>2000</td>
</tr>
<tr>
<td>Bulb color temperature (K)</td>
<td>3.000</td>
</tr>
<tr>
<td>Operating temperature (°C)</td>
<td>5°–35</td>
</tr>
<tr>
<td>Operating humidity (%)</td>
<td>5–95 at 40°C</td>
</tr>
</tbody>
</table>

**Microscan MS-4 Ultra-Compact Imager Barcode Reader**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (mm)</td>
<td>25.4 × 45.7 × 53.3</td>
</tr>
<tr>
<td>Operating temperature (°C)</td>
<td>0–40</td>
</tr>
<tr>
<td>Operating humidity (%)</td>
<td>Up to 90</td>
</tr>
<tr>
<td>Light source</td>
<td>High-output LEDs</td>
</tr>
<tr>
<td>Symbology</td>
<td>2-D: data matrix, QR</td>
</tr>
</tbody>
</table>
AccuRange 200 Triangulating Laser Displacement Sensor

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser (nm)</td>
<td>650 nm</td>
</tr>
<tr>
<td>Resolution</td>
<td>±0.03% of full scale</td>
</tr>
<tr>
<td>Operating temperature (°C)</td>
<td>0–60</td>
</tr>
<tr>
<td>Linearity/accuracy (%)</td>
<td>±0.2</td>
</tr>
</tbody>
</table>

Software

Open the SHMSL application by double-clicking the icon on the desktop. The application will begin by initializing the Acuity AR200 laser, the Bartington MS2E point source susceptibility probe, and the Ocean Optics USB4000 spectrometer. Ask the PP Tech for assistance in changing the instrument’s measurement parameters (see Setting Measurement Parameters). Once initialized, the logger is ready to measure a section.

The Main Integrated Measurement System (IMS) control screen provides access to data acquisition functions and utilities as well as:

- Program state and system status
- Sample information
- Real-time data display during collection

The IMS immediately initializes the system hardware: the track system is initialized first, finding the home position for the Y- and then the Z-axes. Following that, the laser displacement sensor, magnetic susceptibility probe, and spectrometer are initialized.

Figure 2. IMS Application Main Screen.
Laboratory Apparatus

- Flat spatula for cleaning core surface
- Glad Wrap™ (crystal clear polyethylene)

**Note:** This analysis requires clear polyethylene film such as Glad Wrap™. Saran Wrap™, for example, will not serve.

Standard

Labsphere, Inc. Spectralon white standard, certified at 99% reflectivity.

Setting up the Instrument Sensors

*This section is for advanced users only!*

Each instrument sensor is set up through **Instruments > sensor name > Setup**. The parameters discussed in this section are common for all sensors on the SHMSL.

- **Instrument offset**: track position of the laser where the center of the sensor is over the benchmark’s zero edge.
- **Sensor/Contact width**: physical width of the sensor that makes contact with the core’s surface.
- **Analysis name**: LIMS analysis component (must match LIMS component exactly).
- **Instrument group**: LIMS instrument_group logger name (i.e., SHMSL).
- **Model**: model name of the sensor (from manufacturer).
- **S/N**: serial number of the sensor (from manufacturer).
- **Menu name**: value that appears as the instrument’s menu name.
- **Full name**: value that appears in instrument dialog boxes.
- **Description**: instrument purpose; used in the System Information report.

Setting up the MS2E Parameters
General section

- **Range**: 1 or 10; **must** match the MS2 meter front panel setting!
- **Units**: set to SI per IODP standard practice.

Calibration/Control section

- **Standard name**: standard’s LIMS label_ID component value.
- **Text ID**: standard’s LIMS text_ID component value.
- **Standard’s value**: value provided by Bartington, printed on standard label [convert from CGS to SI before entering this value][DH7].
- **Standard X-offset**: track position (X-axis) of the laser when the center of the MS sensor probe is over the center of the standard.
- **Standard Y-offset**: lift position (Y-axis) when the MS sensor probe is in contact with the standard.
- **Calibration expire**: time in hours between calibrations before calibration expire message returns.
- **Current timestamp calibration**: date and time of last calibration (read only).
- **Remaining time**: time remaining until next calibration (read only).
- **From last calibration**: measured value and correction factor from last calibration (read only).

Setting up the USB4000-VIS parameters
**Set USB4000-VIS Parameters**

### Fixed Acquisition Parameters section
- **Hi cut-off** and **Low cut-off**: determine region of interest (ROI) in the spectrum.
- **Bin size**: width of each channel.
  - **Median filter rank**: number of adjacent channels used to filter noise from the signal.
  - **Illuminant**: = D65; International Commission on Illumination (CIE) standard illuminant used in color calculations (also called daylight illuminant).
  - **Geometry**: = d/8; references integration sphere measurement technique: illumination from a diffuse light source viewed 8° from normal (d/8); includes a gloss trap to exclude spectral reflections.
  - **Observer**: = 10 Degree-2; indicates usage of CIE 1965 standard function in tristimulus calculations.

### Temperature Section
- **Current temperature**: temperature of the spectrophotometer
- **High-temperature threshold**: set the alarm level during calibration; based on experience, 30°C is appropriate. Higher temperatures allow signal deterioration.

### Integration time section
- **Integration time**: time the CCD is exposed; if too short, noise will be high; if too long, the sensor will saturate and clip data.
- **%saturation of the total response**: used by WHITE calibration to determine sample integration time by calculating the integration time required to reach the specified saturation (70%–95%). Note: if cores are
light colored, increase throughput by using a low saturation level; if cores are dark colored, use a high saturation level to improve signal-to-noise ratio.

- **Starting integration time**: beginning time (in seconds) value for WHITE calibration; set to 1 for new bulbs and up to 2 for aged bulbs. This setting has no effect on data from subsequent measurements.[DH8]

### White and Dark calibration Section

- **White standard name**: LIMS label_ID component value (STND-White).
- **White standard LIMS Text ID**: LIMS text_ID component value (WHITE).
- **White standard X-offset**: track position (X-axis; in cm) of laser when the center of the integration sphere sensor is over the center of the white standard.
- **Dark standard name**: LIMS label_ID component value (STND-Dark).
- **Dark standard LIMS Text ID**: LIMS text_ID component value (DARK).
- **Dark standard X-offset**: track position (X-axis; in cm) of laser when the center of the integration sphere sensor is over the center of the dark standard.
- **Standard Y-offset**: lift position (Y-axis) when the integration sphere is in contact with the White or Dark standard (same value for both).
- **Calibration expire**: time in hours between calibrations.
- **Current timestamp calibration**: date and time of last calibration (read only).
- **Remaining time**: time remaining until next calibration (read only).

### Setting the AR200 Parameters

Settings in this screen (Figure 6) are covered in the general settings above.

![Set AR200 Parameters](image)

**Figure 6. AR200 Sensor Setup.**

### Setting up the Galil DMC 18X6 Motion Control
This section is for advanced users only!

1. To access the motion controller setup window, select **Motion > Setup** (Figure 7).

From the DMC Motion Setup window (Figure 8), five setup panels can be accessed:

- Track Configure: Motor and Track Options
- Track Configure: Limit and Home Switches
- Track Configure: Fixed Positions
- Motion Profiles
- Tune Servo

**Track Configure – Motor and Track Options**
Before using this panel you should be familiar with the Galil hardware and command manuals. Values 1 thru 5 are used by IMS to set motion controller parameters and convert encoder pulses into ± position values in centimeters. The parameters in item 6 are used by various functions in the DMC software module. 

Once these values have been properly set you should never, never have to change them. This panel is only used for the initial setup.

**Track Motor and Options**

![Figure 8. Track Motor and Options.](image)

**Track Configure – Motor and Track Options**

Once these values have been properly set you should never, never have to change them. This panel is only used for the initial setup.
Figure 9. Limit and Home Switch Configuration.

Track Configure – Fixed Positions
Motion Profiles
Tune Servo

Setting Measurement Parameters

This section is for advanced users only!

Before measurement parameters can be set or changed the IMS must be unlocked. Note: Changing setup parameters can cause problems. Make sure you know what you are doing before changing any setup parameters.

1. Under File, select Unlock Setup, then have the laboratory specialist type the unlock code into the keypad window.

2. To open the measurement editor, select Track > DAQ Editor.

3. In the Measurement Editor window, loaded instruments are shown in the Select Instrument fields. Click on an instrument to see its measurement parameters in the Instrument Parameters field.

4. Click the Instrument Parameters window to open the editor for that instrument.
5. The MS2E and USB4000-VIS have similar editor screens. From here you can set the following parameters:

- **Sample interval (cm)**: set from 0.1 to 20 cm; intervals for both instruments should either be the same or multiples of one another.
- **Edge (cm)**: how close to measure to an edge (top and bottom of a section as well as edges of voids within the section). The distance is measured from the center of the sensor (MS2E sensor width = 4 mm or 10 mm, depending on orientation; USB4000 sensor width = 8 mm). Edge width = 1.0 cm works well.
- **Average**: number of measurements to take at each position (averaged for the final reported value).
- **Control (on/off)**: whether to measure a mounted control standard at the end of every section measurement.
- **Online (on/off)**: set the instrument online or offline.
6. Click **OK** to save settings to the instrument configuration file and return to the **Measurement Editor**.

7. Only one parameter can be set for the laser, and that is **Gap Detection Offset** (a height below the benchmark that will be tagged as a gap and not measured). For piston cores, this should be set to 10 mm or less. For hard rock cores, set between 20 and 30 mm.

---

### Running Samples

Core-half sections are measured on the SHMSL as soon as possible after splitting so that drying and oxidation do not affect ephemeral sample properties such as color reflectance. Sample preparation includes scraping to clean the core surface and covering wet core samples with plastic wrap to prevent contamination of the contact sensors (Figure 3).

### Preparing Samples

1. Use a spatula to clean the cut surface of the core by lightly scraping away any material that was smeared across the surface during core splitting.
2. Bring the endcap of the section half (A or W) to be measured to the SHMSL. Use the endcap rather than the label on the bottom of the section to scan the barcode for sample information, to prevent accidentally dropping the section half.

3. Place the archive section in the core tray with the blue endcap up against the benchmark. The benchmark is the white square at the head of the rails that hold the section halves.

4. Adjust the section so that it is as flat as possible with respect to the plane of the benchmark. There is a limit to how much the sensor heads can float when they land on a tilted section.

5. Do not wrap the cores yet. The Acuity AR200 laser cannot reliably see through the plastic to measure an accurate profile of the section half surface.

**Measuring Samples**

1. Click the **Start Scan** button to open the **Section Information** screen.

   ![Start Scan](image)

   **Figure 15. Start Scan.**

   a. Place the cursor in the **SCAN** text field so that the barcode information will be parsed appropriately. At the beep, the information will automatically fill for Expedition, Site, Hole, and so on.

   b. Enter **User** (your last name) and **Comments** fields (both fields are optional).

   c. If material is missing from the top of the section, enter the distance in the **Missing Top** field (circled).

   d. **Note:** If material is missing at the top of the section, be sure the section half is positioned all the way up to the top of the rail. The software will add the missing top interval to all of the measurements in the database. For example, if a 150 cm section half has a missing 10 cm at the top, the yellow endcap should be placed against “0 cm” at the top of the instrument’s rails. The user should enter 10.0 in the **Missing Top** (cm) field. The logger will measure the section, and all measurements will be placed at the correct offsets in the database.

   e. Additional intervals can be specified for omission from measurement by clicking the **Exclude Interval** button. Enter the top and bottom offsets of the areas to be excluded during the measurement pass. The excluded intervals apply to all enabled sensors.
2. When the required minimum sample information has been entered, the Start Measurement button becomes active. Click it to start the measurement. If the USB4000 does not require calibration (see USB4000 Calibration), proceed to the next step.

3. The sensor assembly will move down the track while the laser acquires a profile of the split surface of the section. Detected gaps that will not be measured by the sensors are shown on the screen in red. (Gap detection parameters are configurable; ask the PP tech for assistance in modifying them.) Acquisition of this profile is why the section is not yet wrapped in plastic wrap—sometimes the laser will profile the wrap rather than the sediment beneath it and give incorrect heights to the gap detection routine.

4. After the surface profile is completed, the measured section length as determined by the laser is displayed (Figure 18). Apply Glad Wrap to the surface of sediment cores as demonstrated by the PP Tech (Figure 19). Adjust the displayed length if needed in the Section Length field and click GO to start the section measurement.
Figure 5. Final Sample Preparation.

IMPORTANT!!! Before pressing GO, it is necessary to cover the core section with Glad Wrap in order to avoid damage to the integration sphere. Any mud that gets inside the sphere will ruin it!

5. The measurement sequence begins. For efficiency, measurements begin at the bottom of the section and move upcore. Results are displayed during acquisition on instrument graphs on screen. Note that the USB4000 has several tabs that display different views of the color reflectance data. Tabs can be changed during the measurement sequence. The **Normalized Spectra** tab shows the corrected percent color reflectance being measured at each point.
6. After the section has been measured, the logger takes measurements using the MS2E and WHITE standards as check standards.

**Calibrating the Sensors**

Before running the first sample, the software will check the status of each instrument’s calibration. If any instrument needs calibration, a prompt will appear listing out of date calibrations. It is recommended that the user select every instrument that needs calibration and click the **Calibrate** button before continuing. There is an option to ignore one or all calibrations (click **Cancel**), but the calibration list will reappear with every run until the calibrations are completed and data run without a calibration update will be flagged as **calibration invalid** in LIMS.

**Color Reflectance Spectrophotometer (Autocalibration)**

The color reflectance spectrophotometer calibrates on two spectra, pure white (Spectralon WHITE standard) and pure black (DARK standard), mounted in the track’s bench. Color calibration is required approximately every hour. The control program will notify when calibration is due and automatically open the **Calibrate** routine (Figure 5).

**Note:** a calibration may be run at any time outside of the mandatory calibration period.

1. If the USB4000 is out of calibration, the **Instrument Calibration List** screen will appear.
2. Before beginning the calibration, ensure the cap is off the WHITE standard and that there is no debris in the hole (DARK standard).

![Figure 23. WHITE and DARK Standards.](image)

3. Click the **Calibrate ALL CHECKED Instruments** button to begin the calibration process. The logger moves the USB4000 integrating sphere over the WHITE calibration standard and lowers the sensor until it touches. The sensor takes some preliminary measurements to establish the integrating time based on an 80% saturation level of the total response. These measurements take about 0.45 to 0.55 seconds for the current dual-light source configuration, assuming the bulbs are new.

![Figure 10. Integration Time.](image)

Note: if integration times increase to more than 1 second, alert the PP tech. The halogen bulbs in one or both of the light sources may need replacing. If one light source is being used, the expected integration time is 1.0 to 1.8 seconds, and bulb problems are indicated if the integration time rises to more than 2 seconds.
4. Click **Accept** to accept the suggested integration time. The logger will then take 20 measurements of the WHITE standard at the calculated integration time. On the screen (Figure 25):

- **Max Counts**: current highest value
- **Target Counts**: percent saturation value as set in the instrument parameters (range = 32,000 counts)
- **Integration Time**: measurement period where the highest wavelength count is equal to or exceeds the specified percentage of the spectrophotometer’s range. Note: this specified percentage value is set in the instrument configuration, usually at 85%, but can be in the range 70%–95%. The value can be optimized for dark or light rocks (see **USB4000 Sensor Setup**).

![Figure 11. White Calibration Screen.](image)

Note: If overriding the calculated integration time, be aware that this manual value only applies to the actual section measurement, not the calibration integration time. Although the application asks you to click **Manually Set**, there is no button for that option (old feature). Enter the manual value into the dialog window and observe it being applied during the measurement phase. Manually-set integration times are not presently denoted in the files—put it in the sample comment field if you want it to be recorded. **Manual integration times are not recommended.**

5. After the WHITE measurements are completed, the logger will raise the integrating sphere, position it over the DARK standard, and lower it onto the dark standard. The shutters on the light sources will close and the DARK measurement will acquire 20 measurements. The dark measurement is a baseline measurement that includes thermal noise of the system. On the screen (Figure 26):

- **Temperature**: should remain below 30°C
- **Spectral Mean**: mean of the entire spectrum (at the line across the display plot). This should be only about 200 counts higher than the Dark Pixel count. With plastic wrap, it should not exceed 500 counts.
- **Dark Pixels**: 20 pixels that have been deliberately masked to allow no light. These counts represent the thermal noise of the spectrophotometer.
6. The final screen shows the normalization of spectra that will occur with the just-acquired calibration (note: low values are better than high values because of signal-to-noise ratio). Ideally, the graph would display a straight line at zero value. However, a normalization factor is required to be applied to the XYZ and L*a*b* color indexes. Normalization amplifies the noise as well as the signal. If core flow allows, the data quality can be increased by averaging multiple measurements (in Measurement Editor increase the Average parameter).
7. If this was a mandatory calibration the laser profile will start automatically, followed by the normal measurement sequence.

**Spectrophotometer (Manual Calibration)**

To perform calibration manually (not when specified by the software), follow these steps:

1. From the Main control screen, select **Calibration > Calibrate**. Follow the instructions on the screen.
2. The spectrometer arm lowers the sensor to contact the standard and scans the full wavelength interval for \( \sim 30 \) s.
3. Remove the cap from the WHITE calibration standard and place it under the integrating sphere.
4. Do not allow contaminants inside the cap or standard.
5. After the integrating sphere rises and the program prompts, remove the calibration standard from under the sphere.
6. Once the standard is removed, the spectrometer arm lowers again so the integrating sphere sits over the hole above the light trap, where it acquires the DARK spectra for \( \sim 30 \) s.
7. The spectrometer arm raises the sensor to the elevated position and the software automatically calibrates the WHITE reading to 100% reflectance and DARKk to 0% reflectance for comparison with subsequent readings.

**Point Magnetic Susceptibility Meter**

The point magnetic susceptibility meter is calibrated on shore. The sensor is calibrated either directly or indirectly to the diamagnetism of water, where density \( \rho = 1 \). The probe is zeroed in air before each measurement point.

The calibration uses an average of 10 and applies a correction factor; this calibration value is then applied to sample measurements. The MS correction is nearly 1.0 \( \pm 1\% \). If the calibration value is low, check the position of the sensor and make sure it is in full contact with the standard.

![Figure 28. MS Sensor Calibration.](image)

**Sensor Calibration Triggers**

1. **Time**: Calibration expiration time can be set in the **Instrument Setup** screens. Calibration expiration can be set from 1 to 24 h (default = 6 h). The time trigger is independent of number of samples run.
2. **Core number or section number change**: Set this option in Track > Calibrate Setup.

3. **Manual override**.

**Data Handling**

After the core section has been measured, the software generates the following files/reports, which are uploaded into the LIMS upon acceptance (see LIMS Integration):

*C:|data|IN*
- Section half L* a* b* and XYZ data
- MS2E check standard result
- MS2E (MSPOINT) data file
- USB4000 white check standard result
- Laser profile pointer file

*C:|AUX_DATA|PROFILE*

Laser profile data in 0.1 mm steps

*C:|AUX_DATA|RSC|CALIB*

White and Dark calibration spectral data per wavelength (380–900 in 2 nm steps)

*C:|AUX_DATA|RSC|CNTRL*

Raw spectra and normalized (% color reflectance) spectral data per wavelength (380–900 in 2 nm steps) for the white check standard at the end of a run
Raw spectra and normalized (% color reflectance) spectral data per wavelength (380–900 in 2 nm steps) for the measured section

Quality Assurance/Quality Control

Analytical Batch
The analytical batch is defined by the number of samples run between each spectrometer calibration. Each sample in the batch run with the current calibration is associated with that calibration data in the LIMS. If a calibration problem is discovered, all samples in the batch can be identified and rerun.

Accuracy
David had the following notes:

DJH accuracy verification comment: For the reflectance spectrophotometer, I agree that we should scan a different material, which is why we brought the BCRA-calibrated color tiles on board. A check against several of these should be done at least once per day.

DJH precision verification comment: I agree with this assessment. If we're going to do precision statistics, we need to run one section half twice per ~ 20 section halves. We can then compare the data between runs and estimate uncertainty based on precision.] Comment in word text under Precision verification: verifying precision involves running either samples or standard reference materials more than once (separate measurement runs) and calculating the standard deviation. Increasing the number of replicate samples in the LabView algorithm will not provide precision verification. Text is similar to text in precision below.

Magnetic Susceptibility
Measure a well-characterized magnetic susceptibility control sample and compare results with true value and/or whole-core track results.

Reflectance
Measure a second standard, standard reference material, or characterize a material in-house to use as a control.

Precision
Run samples or standard reference materials more than once (separate measurement runs) and calculate the standard deviation. Increasing the number of replicate samples in the LabVIEW algorithm will not provide precision verification.

LIMS Integration

LIMS Components
Results are stored in the LIMS database associated with an analysis code and an analysis component. Analysis codes and their components and units are listed below.

Magnetic Susceptibility

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Component</th>
<th>Definition</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSLP</td>
<td>comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>instrument_group</td>
<td>contact core logger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>magnetic_susceptibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>offset</td>
<td>offset on sample</td>
<td>cm</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>run_cumulusid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>run_dimame</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>run_filename</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MSLP_QAQC**

- comment
- drift_measure_end
- drift_measure_start
- elapsed_time
- magnetic_susceptibility

### Color Reflectance Spectrophotometry

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Component</th>
<th>Definition</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSC</td>
<td>cielab_a_star</td>
<td>a*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC</td>
<td>cielab_b_star</td>
<td>b*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC</td>
<td>cielab_l_star</td>
<td>L*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC</td>
<td>munsell_hvc</td>
<td>Munsell color estimate</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>cielab_a_star</td>
<td>a*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>cielab_b_star</td>
<td>b*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>cielab_l_star</td>
<td>L*</td>
<td>fraction</td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>munsell_hvc</td>
<td>Munsell color estimate</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_x</td>
<td>x-axis</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_y</td>
<td>y-axis</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_z</td>
<td>z-axis</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>offset</td>
<td>offset on sample</td>
<td>cm</td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>rsc_filename</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_x</td>
<td>x-axis</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_y</td>
<td>y-axis</td>
<td></td>
</tr>
<tr>
<td>RSC_QAQC</td>
<td>tristimulus_z</td>
<td>z-axis</td>
<td></td>
</tr>
</tbody>
</table>

### Uploading Data to LIMS

As with most laboratory data, uploading SHMSL data to the LIMS database is executed via the **MUT** application. Look for an icon on the bottom menu of the Desktop (shown by the red triangle below) or the more prominent “Puppy” MUT Icon (usually on the Desktop). Double-click on one of these application launchers.

![MUT Icons](image)

**Figure 31. MUT Icons.**

The user must log in using database credentials to use MUT. Once the application is activated, it displays a table-like list of files in the `C:\DATA\IN` directory. Files are ready to be uploaded if they have a green check mark next to them.
Once the **Upload** button is clicked or the **Automatic Upload** option is checked, files will be transferred to the LIMS database via MUT and then moved to the *archive* folder. The presence of files in the *Archive* folder is the indication that they have been uploaded to the database.

- Purple question marks on files in MUT indicates that MUT cannot identify them.
- Red and white X icons on files in MUT indicate errors associated with the files.

Please ask a technician for help if you see these indications.

### Health, Safety, & Environment

#### Safety

- Keep extraneous items and body parts away from the moving platform, belt, and motor.
- The track system has a well-marked emergency stop button to halt the system if needed.
- Do not look directly into the spectrometer light source.
- Do not look directly into the laser light source.
- Do not attempt to work on the system while a measurement is in progress.
- Do not lean over or onto the track.
- Do not stack anything on the track.
- This analytical system does not require personal protective equipment.

#### Pollution Prevention

This procedure does not generate heat or gases and requires no containment equipment.

#### Waste Management

Dispose of soiled Glad Wrap™ in an approved waste container.

### Maintenance/Troubleshooting

#### Common Issues

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS sensor: baseline drift</td>
<td>Temperature variations</td>
<td>Ensure operating temperature is constant</td>
</tr>
</tbody>
</table>
### International Ocean Discovery Program

#### SHMSL User Guide DRAFT

**and preferably cool**

Make sure samples have equilibrated to room temperature

<table>
<thead>
<tr>
<th>MS sensor: reading fluctuations greater than ±1 least significant digit</th>
<th>External electrical noise</th>
<th>Check the operation area for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track is “stuck”</td>
<td>Gantry flag has tripped the end-of-travel limit switch</td>
<td>Adjust gantry flag and run sample again</td>
</tr>
<tr>
<td>Current limit on motors was exceeded</td>
<td>Call PP tech or ET to reset motor controller</td>
<td></td>
</tr>
<tr>
<td>Torque limit on motors was exceeded.</td>
<td>Call PP tech or ET to reset motor controller</td>
<td></td>
</tr>
<tr>
<td>Power supply voltage too low</td>
<td>Check power supply input voltage</td>
<td></td>
</tr>
<tr>
<td>Ambient light level too high</td>
<td>Reduce ambient light level</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laser sensor: no laser light/no laser range data</th>
<th>Configuration data lost</th>
<th>Press function button to restore factory default configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser sensor: LED flashes continuously at 1 Hz</td>
<td>Calibration data lost</td>
<td>Contact manufacturer</td>
</tr>
</tbody>
</table>

### Scheduled Maintenance

**Daily**

- Keep contact sensors and laser window clean by wiping with a Kimwipe.
- If necessary, use isopropyl alcohol to remove soil from sensors and laser window.
- Do **not** use **any other solvent**!

**Annually**

- Remove the end covers on the linear actuators and check if the motor belts need tightening.
- Examine the cable management system for abraded cables or other indications of wear.
- Remove the top covers of the linear actuators and check the ball screws to see if they need cleaning or additional lubrication.

**When Needed**

- If the reflectance standard becomes nicked or soiled, it can be smoothed, flattened, and cleaned.

### Vendor Information and Part Numbers

**Reflectance Spectrometer**

**Vendor**

Ocean Optics, Inc.

- [www.oceanoptics.com](http://www.oceanoptics.com)
- [info@OceanOptics.com](mailto:info@OceanOptics.com)
- 727-733-2447

**Parts:**

- Spectrometer: PN USB4000-UV-VIS
- Light source: PN HL-2000-FHSA or HL-2000-FHSA-LL
Spare bulb: PN HL-2000-B or HL-2000-LL-B  
Reflectance standard: PN WS-1-SL

**Magnetic Susceptibility Meter**

**Vendor:**
Bartington Instruments, Ltd.
www.bartington.com  
sales@bartington.com  
44-1993-706565

**Parts:**
Meter: PN MS2  
Sensor: PN MS2F

**Laser Displacement Sensor**

**Vendor:**
Acuity Laser Measurement  
www.acuitylaser.com  
702-616-6070

**Parts:**
Sensor: PN AR200

**Barcode Reader**

**Vendor:**
Microscan  
www.microscan.com  
helpdesk@microscan.com  
800-251-7711

**Parts:**
Embedded barcode reader: PN MS-4

**Related Documentation and Links**

- Servo motor data sheet: blm_n23.pdf  
- Ocean Optics Fiber Optic Spectrometer Operation Manual: USB4000operatinginstructions.pdf  
- Microscan MS-4 Ultra-Compact Imager data sheet: ms4spec.pdf  
- Bartington MS2 Magnetic Susceptibility sensors data sheet: MS2 sensors D50020.pdf  
- Bartington MS2 Magnetic Susceptibility system operation manual: OM0408 MS2.pdf  