CONTENTS

INTRODUCTION .......... 1
WARRANTY ............. 1
DESCRIPTION .......... 2
Refracting Prism Assembly .......... 2
Eyepiece ............ 2
Measurement Scales .......... 2
Compensator System .......... 4
OPERATING PROCEDURES ......... 4
General ............. 4
Instrument Calibration .......... 5
Liquid Samples .......... 5
Solid Samples .......... 6
Opaque Samples .......... 6
Temperature Control .......... 6
Water Bath Control .......... 7
Thin Film Measurements .......... 8
Determination of Dispersion .......... 8
MAINTENANCE .......... 8
Lamp Replacement .......... 8
Prism Assembly Removal & Replacement .......... 3
Mercury Separation .......... 9
INTERNATIONAL SUCROSE TABLES .......... 10-11
ACCESSORIES .......... 12
DESCRIPTION

The Abbe-3L consists of a refracting prism assembly (with illuminator), an internal measurement scale, and a compensating prism system.

REFRACTING PRISM ASSEMBLY

The prism assembly consists of an upper and lower prism case, each containing a separate prism. The upper case contains the illuminating prism and the lower case contains the measuring prism. The upper case is opened with the handle on the right-hand side.

In use, the nD of liquid samples is measured by introducing a thin film of sample between the upper and lower prisms; the nD of solid samples is measured by placing them in optical contact with the surface of the measuring (lower) prism with a suitable contact liquid.

In both cases, the sample/prism interface generates a "total reflection" borderline which is visually observed through the instrument eyepiece. This total reflection borderline is used to determine the nD of the sample.

The prism cases are hollow to allow for the optional circulation of constant temperature liquid. A thermometer in the input line provides an accurate indication of the liquid temperature. A short external jumper carries the liquid to the upper prism case.

Prism Identification Number

The particular series of prism glass used in your Abbe-3L is identified by a number found on the right-hand side of the measuring prism. This number can be seen by opening the upper prism case and holding a light near the lower prism. This number MUST match the scale series number described below and must be given along with the instrument serial number, in all correspondence or parts orders for your instrument.

The lower prism case has a small, hinged shield which prevents stray light from entering the front of the measuring prism. This shield can be swung down for measuring opaque samples.

Prism Illumination

The total reflection borderline, as seen in the instrument eyepiece, is the dividing line between a light and a dark sector. The required illumination (white light) is given by the "Field Lamp" located at the end of the adjustable arm. The lamp is housed inside the rotating lens assembly which also contains a lamp shield and diffuser. The arm assembly can be moved up or down and the lens rotated for optimum illumination of the prism, as shown by maximum definition in the reflection borderline. The field lamp is turned on when the combined power/lamp selector switch on the left panel is in the center position.

EYEPiece

The eyepiece is used to observe both the total reflection borderline and the instrument's internal measurement scales. It normally provides a 2X magnification. A dual reticle provides precise settings on the reflection borderline and accurate readout of the measurement scale.

MEASUREMENT SCALES

The instrument contains two coincident scales which read from 1.50 to 1.71 nD and from 0-65% total dissolved solids. The scales are visible through the instrument eyepiece when the power/lamp selector switch is depressed to its lower position.

The eyepiece should be focused for the best image of the reticle and scales. The "Total Dissolved Solids" scale is based directly on the 20°C ICUMS A Table of 1966.

Turning the handwheel on the right-hand side of the instrument moves the scales (and total reflection borderline) across the reticle.

When the scales are set to their extreme low end, a small 3-digit number will be seen. This number (the prism identification number) MUST match that found on the side of the measurement prism.
The Abbe-IL provides maximum precision with quick, easy operation. To maintain its performance, keep it clean at all times and pay particular attention to the care of the measuring prism:

1. Use a non-ionic detergent to clean the prisms after each sample and keep the upper prism closed when not in use. The prism glass is quite soft and easily scratched.

2. The spacer around the prisms is an epoxy resin which is resistant to most materials. However, there are a few solvents which are known to attack it and which must not be used with the instrument:
   a. N,N - Dimethylformamide.
   b. Phenols, cresols, and other tar acids.
   c. Acetic acid solutions.
   d. N,N - Dimethylacetamide.

   The following materials will attack the sealer over a long period of time or at elevated temperatures:
   a. Tetrahydrofuran.
   b. Mixtures of esters, especially methyl acetate and vinyl acetate.
   c. Some lacquer thinners.

   If in doubt about the sample/sealer compatibility, please contact the nearest Milton Roy regional office.

3. Strong mineral acids and bases will quickly fog the prisms and must not be used.

4. Use the handwheel and center the reflection borderline exactly on the reticle cross hairs.

5. Depress the handwheel and note the index value. It must coincide with the value engraved on the test piece. Repeat measurement several times, centering the reflection borderline both above and below the cross intersection.

6. Release the switch and position and the field lamp arm and shield for the best contrast and definition at the reflection borderline.

NOTE
It may help to rotate the lamp lens to the diffused position.

7. Rotate the Compendium Dial until the achromatic section of the borderline is centered on the vertical reticle mark.

8. Use the handwheel and center the reflection borderline exactly on the reticle cross hairs.

9. Depress the handwheel and note the index value. It must coincide with the value engraved on the test piece. Repeat measurement several times, centering the reflection borderline both above and below the cross intersection.

10. If the index displayed does not coincide with the test piece, insert the knob into the hex screw on the right-hand side of the handwheel, and adjust the test piece to the test piece value.

**GENERAL**

**OPERATING PROCEDURES**

**INSTRUMENT CALIBRATION**

Each instrument is supplied with a calibration test piece used to check and adjust the accuracy of the index scale reading. To calibrate the instrument:

1. Connect the power cord with external transformer to a standard 115VAC 60/60 Hz outlet and depress the power/lamp switch.

2. Open the top prism. Thoroughly clean the measurement prism and the test piece. Use care not to scratch the glass surfaces.

3. Apply a small drop of 1-Bromonaphthalene contact liquid to the prism.

4. Place the test piece on the contact liquid, polished end toward the illuminator. Move the test piece to completely fill the contact area. Do not allow any excess 1-Bromonaphthalene to "bead" at the edges.

5. Depress the power/lamp switch and use the handwheel to set the index scale (visible through the eyepiece) to the value engraved on the test piece. Focus the eyepiece for the best definition of the reticle and scale.

**LIQUID SAMPLES**

- 1. Insure that the prisms are also clean and refer to the section on "Texture Control."

- 2. Turn on the instrument. Open the prism case and apply the sample directly to the measurement prism with the dropper. Use care not to touch the prism with the dropper. If the sample is viscous, use a wooden or plastic spatula. NEVER USE GLASS OR METAL.
APPLICATORS ON THE PRISM
FACE. Insure that sufficient sample has
been loaded to completely fill the space
between prisms. Close the prism case.

NOTE
If bubbles form in the sample, they may
sometimes be eliminated by slightly open-
ing and closing the prism case. If this is
not effective, re-clean the prism surfaces.

3. Adjust the illuminator for the best con-
trast in the reflection borderline. Using
the handwheel, set the borderline on the
cross hair intersection, and achromatize
it with the Compensator DIAL.

4. Depress the contact switch and read the
sample value in index of refraction (nD)
or % total solids.

SOLID SAMPLES
To accurately measure the index of a solid
sample, it must meet the following require-
ments:

a. The contacting surface must be flat to
every .0001 wavelength.
b. It must have a sharp right angle edge.
c. The material must be homogeneous.

Open the top prism case and insure that
the measurement prism is absolutely
clean.

5. Using a suitable contact liquid, place the
sample on the measurement prism with
the sharp edge toward the illuminator
and flat side down. NOTE: The 1-Bromo-
naphthalene is suitable for samples with
an index up to 1.65 D. For samples with
a higher index, use methylene iodide.

6. Adjust the illuminator for the best con-
trast in the reflection borderline. Set the
borderline on the cross hair intersection,
and achromatize it with the Compensator
DIAL.

7. Depress the contact switch and read the
sample value in index of refraction (nD).

In general, the temperature coefficient
of index change is so small in solid materials
that temperature control is not required.
However, with some of the newer plastics
this may not be true, and if in doubt the
temperature coefficient should be checked.

Opaque Samples
Refractive index measurements are seldom
required on opaque materials, but when it is
necessary to obtain such a reading the reflec-
tion method must be used which is, at
best, not very satisfactory.

When measuring by reflection, the sample
is attached to the prism with the usual
contact liquid, the light shield on the measur-
ing prism is swung down, and the light from
the illuminator is directed toward the shield.
The illuminator arm and shield are then
adjusted for the most favorable reflection
borderline.

In the reflection method, the borderline is
very indistinct because of the lack of contrast
between the two halves of the field. This is
inherent in any Abbe type instrument and
cannot be avoided. Sometimes the line can
be seen only when it is in motion across the
field. Then it may help to move the border-
line past the cross hairs with a constantly
decreasing motion until it can no longer be
distinguished. In using this method, take a
number of readings, approaching the cross
hairs from above and below.

In order to use the reflection method,
experimental readings may be made using
paraffin oil. With it, the borderline may be
set by the usual transmission method and
then observed in reflection. This will aid in
recognizing the characteristics of a reflec-
tion borderline.

TEMPERATURE CONTROL
Various materials differ greatly in their
chances of index with change in tempera-
ture. The degree of temperature control
required depends on the nature of the sample
and the desired accuracy of the reading.
Most of the vegetable and mineral oil and
fats, for example, have temperature coeffi-
cients in the order of 0.0004 to 0.0005 D
per degree centigrade and must have close
temperature control for accurate and con-
sistent results.

Correction tables have been prepared for
many materials whose refractive index is
commonly determined. Readings may be
made at any normal ambient temperature.

1. Outlet Hose
2. Jumper Hose

FIGURE 7. Abbe-3L Hose Connections

and the values at a standard temperature
computed using the correction factor
obtained from the table.

The International Sucrose Tables in this
manual are published with correction fac-
tors related to the 20°C standard tem-
perature, instrument temperature cont-
rolled value is not needed, but the room
ambient temperature remain constant for a reasonable
time to allow the prism temperature to
balance. NOTE: The sucrose correction
are the only tables furnished by Mil

NOTE
The built-in thermometer (33-45-
not agree exactly with the therm
supplied with an external water circula
tor is because the thermometers are
at different locations. Neither of these is
exactly the same as the sample loca
greatest accuracy, the user may
make a correlation between one
thermometer and the actual temp
at the sample location as measured
small, accurately calibrated value
placed directly between the closed

WATER BATH CONTROL
For those applications which require
close temperature control, an external
water/thermostat circulating unit is rec
Models are available which provide
only, or a combination of heating.
When using an external circulator:

1. Follow the instructions supplied
with the unit.
2. Connect the circulator water out
and connect to the Abbe meter.

3. Use caution when operating at
high temperatures. The water temp
must be raised and lowered slowly
vent a possible cracked prism.
4. The Abbe 3-L Refractometer is des
for use up to 80°C. If you wish to
occurrences over 80°C, contact
Technical Support
Analytical Products Division
Milton Roy Company
820 Linden Avenue
Rochester, New York 14625
or telephone:
Continental U.S. 1-800-4-
**Determination of Dispersion**

The Milton Roy Abbe-3L can be used to determine the following optical parameters:

a. Dispersion

b. \( \nu \) (Nu Value or Abbe Number)

In these applications, it is essential that the compensator be in good working order, i.e., the two positions of the Compensator Dial which produce an achromatic reflection borderine must occur at identical dial settings on each side of the dial zero mark.

a. Dispersion Measurement - Dispersion is measured as \( \nu = \frac{nD - 1}{nP - nC} \), using the instructions and values given in the "Dispersion Table" furnished with the instrument. **NOTE:** The series number of the "Dispersion Table" MUST match the series number of the instrument prism and scale.

b. Nu Value - Determined from the equation:

\[
\nu = \frac{nD - 1}{nP - nC}
\]

**Maintenance**

The Abbe-3L is a rugged, trouble-free instrument which needs a minimum of routine maintenance. Customer repairs are limited to lamp and thermometer replacements and prism assembly replacements ONLY. Do not attempt to make any repairs or adjustments on the internal components of the instrument. If service is required while the instrument is under warranty and it was purchased from a dealer, contact the dealer. If purchased from Milton Roy, contact the Milton Roy Field Service Center. If service is required when the instrument is out-of-warranty, it may be returned to the Field Service Center, regardless of the purchase location.

**Lamp Replacement**

Unplug instrument before replacing lamp.

1. Scale Illuminator Lamp

**Figure 3. Bottom View**

b. Remove the screws holding the prism insulator to the instrument and remove the lower prism unit.

Spare prism assemblies (of a given series) are available for your Abbe-3L. If a replacement prism is required, **BE SURE THE PRISM SERIES NUMBER MATCHES THE SERIES NUMBER ON THE INDEX SCALE.**

To reassemble the prism assembly:

a. Apply a thin bead of adhesive/sealant (RTV silicone rubber) along the perimeter of the prism case insulator before fastening the lower prism case to the instrument and tighten the four screws.

b. Attach the hinge and upper prism to the lower case. When securing the hinge, press down on the closed upper prism to ensure that the prism cases are in contact and parallel to each other.

**Mercury Separation**

Separation of the mercury column thermometer can be caused by mechanical shock and is the most common source of error in thermometer readings. The liquid should be made before detecting any separation in the capillaries of the mercury drop. Mercury can be reunited without harming the thermometer using the following method:

1. Unscrew the thermometer assembly from the instrument and unscrew the guard tube.

2. Dip the thermometer bulb into a freezing mixture until the mercury contracts into the bulb. Remove the thermometer and allow it to warm at room temperature. The column usually appears reunited. This should be tried several times.

3. Mercury may sometimes be reunified by gently warming the bulb over a flame. The mercury column is gradually forced into the upper expansion chamber.
If the thermometer is held in a vertical position to cool, the mercury will recede as a reunited column. CARE MUST BE TAKEN TO PREVENT THE MERCURY FROM COMPLETELY FILLING THE EXPANSION CHAMBER.

INTERNATIONAL SUCROSE TABLES

The "Total Dissolved Solids" scale, visible in the instrument eyepiece along with the index scale, is based directly on the International Sucrose Tables as agreed upon by the Fourteenth Session of the International Commission for Uniform methods of Sugar Analysis (ICUMSA), held in Copenhagen in 1966.

These tables are based on the index values of pure sucrose solutions. When substances other than sucrose are in the solution, the refractometer reads the combined index as % total dissolved solids and not as % sucrose.

The instrument scale is based on the 20°C tables. This manual contains the 20°C tables, along with correction factors for other temperatures.

NOTE

Abbe-3L's manufactured prior to August 1980 were calibrated to the 1936 ICUMSA Scale. These instruments will read 1.5033 on the np scale when the "Total Dissolved Solids" scale is at 85%. Instruments with 1956 ICUMSA Scales will read 1.50406 at the 85% setting.

A Correction Thermometer, Cat. No. 33-45-21, is available as a replacement for the standard instrument thermometer. It quickly indicates the correction required when the instrument is used at temperatures other than 20°C. The maximum error - found only at the extremes of the temperature range and % solids scale - is only 0.2%.

---

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Per cent Sucrose</th>
<th>Add to the per cent Sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>3</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>4</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>6</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>7</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>8</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>9</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

---

| International Scale (1936) of Refractive Index of Sucrose Solutions at 20°C |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent | Index | Per cent |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1.3339                       | 0                           | 1.3723                       | 25                          | 1.4299                       | 50                          | 1.4478                       | 79                          |
| 1.3344                       | 1                           | 1.3740                       | 26                          | 1.4221                       | 51                          | 1.4403                       | 77                          |
| 1.3359                       | 2                           | 1.3756                       | 27                          | 1.4243                       | 52                          | 1.4322                       | 77                          |
| 1.3375                       | 3                           | 1.3772                       | 28                          | 1.4264                       | 53                          | 1.4255                       | 78                          |
| 1.3388                       | 4                           | 1.3793                       | 29                          | 1.4286                       | 54                          | 1.4185                       | 78                          |
| 1.3403                       | 5                           | 1.3813                       | 30                          | 1.4308                       | 55                          | 1.4117                       | 77                          |
| 1.3412                       | 6                           | 1.3825                       | 31                          | 1.4329                       | 56                          | 1.4047                       | 76                          |
| 1.3433                       | 7                           | 1.3847                       | 32                          | 1.4351                       | 57                          | 1.3978                       | 76                          |
| 1.3448                       | 8                           | 1.3866                       | 33                          | 1.4374                       | 58                          | 1.3910                       | 76                          |
| 1.3455                       | 9                           | 1.3884                       | 34                          | 1.4398                       | 59                          | 1.3843                       | 76                          |
| 1.3475                       | 10                          | 1.3893                       | 35                          | 1.4419                       | 60                          | 1.3778                       | 76                          |
| 1.3494                       | 11                          | 1.3902                       | 36                          | 1.4441                       | 61                          | 1.3713                       | 76                          |
| 1.3509                       | 12                          | 1.3911                       | 37                          | 1.4464                       | 62                          | 1.3649                       | 76                          |
| 1.3523                       | 13                          | 1.3920                       | 38                          | 1.4487                       | 63                          | 1.3586                       | 76                          |
| 1.3541                       | 14                          | 1.3927                       | 39                          | 1.4511                       | 64                          | 1.3523                       | 76                          |
| 1.3567                       | 15                          | 1.3936                       | 40                          | 1.4535                       | 65                          | 1.3461                       | 76                          |
| 1.3573                       | 16                          | 1.4018                       | 41                          | 1.4558                       | 66                          | 1.3400                       | 76                          |
| 1.3588                       | 17                          | 1.4037                       | 42                          | 1.4582                       | 67                          | 1.3340                       | 76                          |
| 1.3595                       | 18                          | 1.4057                       | 43                          | 1.4606                       | 68                          | 1.3280                       | 76                          |
| 1.3621                       | 19                          | 1.4077                       | 44                          | 1.4630                       | 69                          | 1.3221                       | 76                          |
| 1.3636                       | 20                          | 1.4097                       | 45                          | 1.4654                       | 70                          | 1.3162                       | 76                          |
| 1.3655                       | 21                          | 1.4118                       | 46                          | 1.4678                       | 71                          | 1.3104                       | 76                          |
| 1.3672                       | 22                          | 1.4138                       | 47                          | 1.4703                       | 72                          | 1.3046                       | 76                          |
| 1.3689                       | 23                          | 1.4158                       | 48                          | 1.4728                       | 73                          | 1.2988                       | 76                          |
| 1.3704                       | 24                          | 1.4179                       | 49                          | 1.4753                       | 74                          | 1.2931                       | 76                          |
**ACCESSORIES AND REPLACEMENT PARTS LIST**

<table>
<thead>
<tr>
<th>CATALOG NO.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>33-46-10</td>
<td>Abbe-3L Refractometer, complete, for 115V, 60/60 Hz operation only; with index range from 1.30 to 1.71nD, includes glass test piece, thermometer, bottle of 1-Bromonaphthalene contact liquid, calibration wrench, dust cover, operator's manual, and dispersion tables</td>
</tr>
<tr>
<td>33-4610-201</td>
<td>Plastic Dust Cover</td>
</tr>
<tr>
<td>33-45-21</td>
<td>Thermometer direct reading in &quot;total solids&quot; corrections, &quot;0&quot; ring and mounted bushing</td>
</tr>
<tr>
<td>33-45-27</td>
<td>Thermometer assembly, 0-100°C, in 1° divisions</td>
</tr>
<tr>
<td>33-45-24</td>
<td>Thermometer, 0-100°C, in 1° divisions, &quot;0&quot; ring and mounted bushing</td>
</tr>
<tr>
<td>33-46-11</td>
<td>Replacement Prism Set, for 33-46-10. Please mention series number of prism and serial number of instrument when ordering.</td>
</tr>
<tr>
<td>33-46-68</td>
<td>Standard Eyepiece, 2X, as supplied with standard instrument</td>
</tr>
<tr>
<td>33-45-81</td>
<td>7 ml bottle Bromonaphthalene, for use as contact liquid for test pieces and other solid samples with indices less than 1.64nD</td>
</tr>
<tr>
<td>33-45-85</td>
<td>Test Piece, Nominal Index of 1.522nD, as supplied with each 33-46-10</td>
</tr>
<tr>
<td>33-33-46</td>
<td>G2316 Lamp, used for sample and scale illumination</td>
</tr>
<tr>
<td>334610-233</td>
<td>Compensator Dial Cover, Magnetic</td>
</tr>
<tr>
<td>334556-275</td>
<td>Calibration Wrench, 6/64&quot;</td>
</tr>
</tbody>
</table>

**BIBLIOGRAPHY**