1230-E26

Abbe Refractometer

NAR-3T

Instruction Manual **Cat.No.1230**

ATAGO®

Contents

Page

1. Precautions for use 2
2. Refractive index and Brix 8
3. Unpacking and Setting-up 9
4. Names and Functions of main parts
   (1) Main unit of NAR-3T 10
   (2) Digital thermometer 13
   (3) How to use Illuminator Selector Switch 13
5. Preparation for measurement
   (1) Preparation of refractometer 14
   (2) Connection with circulating constant temperature bath 15
6. Power-on 17
7. Calibration (Scale adjustment) 18
8. Measurement of liquid sample 23
9. Measurement of solid sample 25
10. Measurement of powdered sample 27
11. Situations that may require additional attention 29
12. Finding average dispersion value and Abbe number 31
13. Cleaning and maintenance 36
14. Replacement of consumable supplies and component parts 37
15. Relation between Brix percent and refractive index (nD) 44
16. Temperature correction table for sucrose solution 45
17. Specifications 46
18. Repair and warranty 47
19. ATAGO CO.,LTD. Service Center 48

1. Precautions for use

Introduction

Thank you for purchasing the "ATAGO, Abbe Refractometer NAR-3T". Before using your NAR-3T, read this instruction manual carefully and understand how to use it. After reading this manual, keep it on hand for future reference.
In this manual "For safe use" describes the important items necessary for safety. Read it carefully.

For safe use --- Be sure to observe the following.

This operation manual describes the items which you are required to observe in order to use the NAR-3T safely to prevent injury to you and other people and damage to your property.
The explanation of the indications and symbols of those items are as follows. Understand them first and then read the following pages to use your NAR-3T correctly.

Explanation of indications

⚠ **WARNING**	If this indication is neglected and the instrument is handled incorrectly, the user may be seriously injured and may result in death.
⚠ **CAUTION**	If this indication is neglected and the instrument is handled incorrectly, the user may be injured and the user's property may be damaged.

Explanation of symbols

⚠	This symbol denotes an item which you are warned (or cautioned) of. The contents of warning are described in detail in or near the △.
⊘	This symbol denotes an action which you must not do (a prohibited item). The contents of prohibition are described in detail in or near the ○.
❗	This symbol denotes an action you must do. The contents of instruction are described in detail in or near the ●.

Handling of this instrument

⚠ WARNING

◇When measuring a substance harmful to the human body, be well aware of its properties and put on protective gloves, mask, etc.



◇If the instrument begins to smell abnormally, overheat, or emit smoke, turn off the power switch and disconnect the power plug immediately.
Fire or malfunction may result if the instrument is continued to be used.
Ask your ATAGO distributor for an inspection.



◇Do not attempt to repair, modify, or disassemble the instrument yourself.
Improper servicing may result in fire, electrical shock, or burns.



◇If the instrument is dropped or is subjected to a strong shock, have it inspected by an ATAGO distributor.
Fire or malfunction may result if the instrument is used.



⚠ CAUTION

◇Do not apply water or sample over any part other than the surface of the prism.
Application on any other part of the instrument may result in a malfunction.



◇If this instrument is used to measure very hot or highly acidic sample, the prism may be damaged resulting in inaccurate measurements.



Handling of this instrument (Continued)

⚠ CAUTION

◇The prism is made of optical glass. Do not tap or contact its surface with any metal tool such as a spoon or tweezers. If the surface of the prism is damaged, inaccurate measurements will occur.



◇ After taking a measurement, completely wipe off any sample on the surface of the prism and surrounding area with tissue paper soaked in water.
Then remove any remaining moisture completely with dry tissue paper.



◇If you have measured a sample of polymer or fats and oils, wipe it off with tissue paper soaked in alcohol or neutral detergent.
Then remove any remaining moisture completely with dry tissue paper.



◇ Always turn off the power switch after use.



◇When transporting the instrument, place it in its original box.



◇ Carefully read this instruction manual and fully understand the function and operation of each part of the instrument before use.
◇ Check that each part of the instrument operates normally before use.
◇ Check the necessary operations such as calibration according to the instruction manual.
◇ The ATAGO shall not be held responsible for any or all damages as a result of use of the instrument for those other than its intended purposes (measurement of Brix, sugar content, concentration of liquid).
◇ The prism mounted on the sample stage that is in contact with a sample under measurement is a consumable item.
◇ Ensure that if use of the instrument has undesired effects on the consumption of the measured materials, etc., ATAGO shall not be held responsible for the result.

Handling of plug

⚠ WARNING

◇Don't plug the power cable into an outlet other than AC100 to 240V.
Inserting the power plug in any other outlet may result in shortcircuiting the unit, smoking or fire.



◇Do not use the power cable if damaged or broken.
If used, fire, electrical shock, or burns may result.
For a new power cable, contact your ATAGO distributor.



⚠ CAUTION

◇Do not insert or disconnect the power plug with wet hands.



◇Be sure to hold and pull the plug when disconnecting the power cable from the outlet.
If the cable is pulled improperly, the plug may be broken, and may result in fire or electrical shock.



Connection of circulating constant temperature bath

⚠ WARNING

◇Pay careful attention to hot circulating water.



◇For connecting a circulating constant temperature bath with the refractometer, make sure to use the elicon tube (made of vinyl chloride).
Moreover, tightly fasten each joint part between the nozzle and tube with the tie band.



◇If the tube is damaged, replace it with new one as immediately as possible.
If the damaged tube is continuously used, the operator may scald himself with hot circulating water.

◇The temperature of hot water to be supplied from a circulating constant temperature bath to this refractometer is limited to 50℃, and the flow rate of the circulating constant temperature bath should be 10 L/min. at maximum through a nozzle of 6mm caliber.
Too much discharge not only increases water pressure but also may cause disconnection between the nozzle and tube or may overload the water channel inside the refractometer.



Items to be observed when using

Environmental conditions

◇Use the instrument at an altitude below 2,000m (above sea level).
◇Use the instrument indoors.
◇Use the instrument on a flat and level surface such as a desk or table.
◇Use the instrument where the temperature is between 5 to 40℃.
◇Do not leave the instrument in a location exposed to direct sunlight or near a heating unit where the temperature may rise.
◇Do not change the environmental temperature of the instrument suddenly.
◇Do not place the instrument in a place where it may be subject to strong vibrations.
◇Do not use the insrtument where there is much dust.
◇Do not leave the instrument where the temperature is extremely low.
◇Do not leave the instrument in a damp place.
◇Do not place or drop heavy objects on the instrument.
◇Use the instrument under the condition where humidity is 80% at 31℃ or lower, falling linearly to 50% at 40℃.
◇Main supply voltage fluctuation should not to exceed ±10% the nominal voltage.
◇Installation categories (Overvoltage Categories): II
◇The pollution degree is 2 (according to IEC60664).

Handling

◇Do not drop the instrument or subject it to any strong shock.
◇The power cable may be damaged if mis-handled in any of the following ways.
- Bending the cable.
- Pulling the cable.
- Twisting the cable.
- Placing the cable under heavy objects.
- Catching the cable between objects.

Daily maintenance

◇If the instrument becomes dirty, wipe it with a soft cloth.
◇Do not use benzine, paint thinner, etc. to clean the instrument.

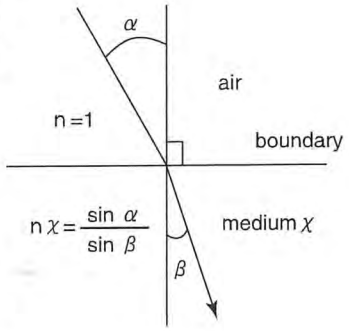
2. Refractive index and Brix

(1) What is a refractometer?

If you put a straw into a glass of water, the straw appears bent. If the water contains concentrations of sugar, the straw will appear more bent. This is called the "phenomenon of light refraction". The refractometer applies this principle (if a solution has a higher concentration, its refractive index rises proportionally). The refractometer is a measuring instrument devised by Dr. Ernst Abbe in Germany in the early 20th century.

(2) What is refractive index?

When light goes to medium x through air with an refractive index of air in the atmospheric pressure assumed as 1, the ratio of the sine of incident angle α against the interface to the sine of refractive angle β is called the refractive index of the medium. Since the refractive index changes due to the temperature, and wavelength of light, it is expressed as follows:



n_D^t
n : Represents the refractive index
t : Temperature(℃)
D : D- line of sodium

For example, the refractive index of water at 20℃ for the D line is expressed as $n_D^{20} = 1.33299$ (generally it is expressed in the form of nD=1.33299).

Note: The refractive index measured by setting the refractive index of vacuum to 1 is called the absolute refractive index, but it is generally scarcely used.

(3) Brix scale

The scale of the NAR-3T is a Brix (%) scale that is based on the refractive index of water (nD=1.33299=Brix 0.0%). Brix means the scale of the weight (%) of sucrose (grams of sucrose contained in 100 grams of sucrose solution). Thus, if a sucrose solution is measured, it matches this concentration. However, almost all foods contain not only sugar, but also a variety of dissolved components such as salt and protein. The total concentration of these water-soluble materials is called the soluble solid content. When this sample is measured, Brix is almost consistent with the soluble solid content (%) and is used as a practical scale.

* The Brix scale is expressed in % mass (Sucrose) as the International System of Units (SI unit).

Note: For relation between Brix percentage and refractive and refractive index (nD), refer to page 44.

3. Unpacking and Setting-up

(1) Unpacking

①Take all contents out of the packing case and check every item whether there is any damage exteriorly or not.
②Confirm the contents so that the following articles have been contained in the package without lack.

- Abbe Refractometer NAR-3T (main unit)……1
- Digital thermometer……1
- AC Power cable……1
- Illuminator Lamp cable……1
- LED lamp……1
- Allen wrench (hex.key wrench) (for calibration)……1
- Test piece……1
- Contact liquid (monobromonaphthalene)……1
- Polishing powder (refer to P.29)……1
- Instruction manual (this book)……1
- Inspection certificate……1

(2) Setting-up

①Connect this refractometer to a mains outlet of AC100 to 240V, 50/60 Hz.
②Set this refractometer in a place where it can be operated at an ambient temperature from 5 to 40℃.
③Since this refractometer has extremely precise component parts inside, set it in an optimum place where it is free from direct rays of the sun, strong vibration, dust, corrosive gas, heat source.
④Set this refractometer on a solid and level surface of a warkbench, etc. When setting, be very careful not to give a strong shock to it.

4. Name and functions of main parts

(1) Main unit of NAR-3T (Figure 4-1, Figure 4-2, Figure 4-3)

① Eyepiece

The field of refraction view and the field of scale view can be observed through the eyepiece. When the lamp is on, the field of scale view is brightly and clearly observed through the eyepiece as shown in Figure 7-4 on page 21. In the upper part of Figure 7-4, the boundary line to be seen between bright part and dark part appears only when the measurement knob is properly operated with a sample on the main prism.

② Sample illuminator lamp holder

A lamp of the sample illuminator is set in the socket. The lamp illuminates the sample penetrating the secondary prism.

③-a,③-b Prism open/shut handles

When this handle ③-a is turned to the front side, the secondary prism is raised by about 1cm. If the handle ③-b is turned leftwards after that, the secondary prism is opened. Since these handles serve as levers, they are very convenient for detaching the main and secondary prisms from each other after measurement of a viscous sample.

④ Secondary prism

When pouring or putting sample on the main prism, the secondary prism must be opened in advance. Since the secondary prism functions to illuminate the sample uniformly, its surface to contact the sample is frosted to diffuse the light uniformly. The standard clearance between the main and secondary prisms is 0.2mm.

⑤ Main prism

The main prism is the most important component for measurement. Pay careful attention to it neither to get it damaged nor to get it corroded. A sample is set on the main prism for measurement. The frames of both the main and secondary prisms are made of stainless steel that has strong corrosion resistance characteristic.

⑥ Reflector for solid measurement

When measuring a solid sample or test piece, lift this reflector upwords.

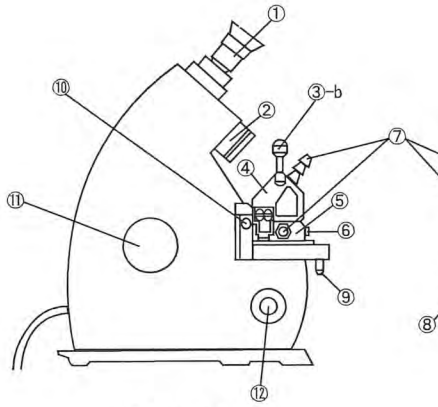


Figure 4-1

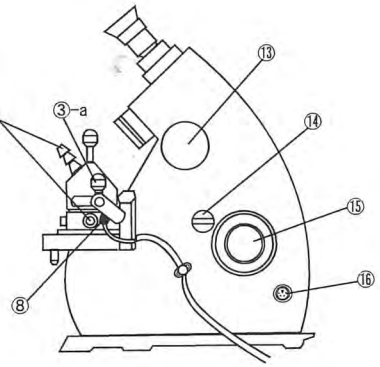


Figure 4-2

⑦ Nozzles for constant temperature circulating bath

These nozzles serve to carry constant temperature water into the periphery of the prism unit. There is a nozzle on each of the right and left sides of the main prism and two nozzles in front of the secondary prism.

⑧ Thermo-sensor

The thermo-sensor that is screwed in the main prism from the side always measures the temperature of the main prism.

⑨ Waste liquid drain nozzle

To drain out sample and water spilled out around the prism unit. When draining, put a liquid container such as beaker, etc. under this nozzle.

⑩ Air nozzle (for defroster)

When the inside of the prism unit is dewed for the reason of cooling, etc., this nozzle is used to drain the dew out of the unit. Turn the cap counterclockwise and the nozzle is exposed. Supply air to this area to remove the condensation inside.

⑪ Scale field illuminator lamp holder

A lamp of the scale field illuminator is set inside.

⑫ Desiccant case

Desiccant tablets inside the desiccant case can be seen through the glass window of the case.
The green color of the desiccant gradually fades as it gets close to saturation.
When it becomes pale green, turns the lid counterclockwise to open and replace it with a new one.

⑬ Color compensator knob (dispersion scale)

The color compensator knob is used to achromatize the boundary line appearing in the field of refraction view. This knob also serves as the dispersion scale, in other words, average dispersion value (nF-nC) can be known by reading this scale as the boundary line is achromatized.

⑭ Calibration screw (scale adjustment)

When the cap is removed by counterclockwise turning, the head of calibration screw is exposed. Calibrate the scale with this screw. Use the Allen wrench (hexagonal key wrench) supplied as an accessory for turning this screw.

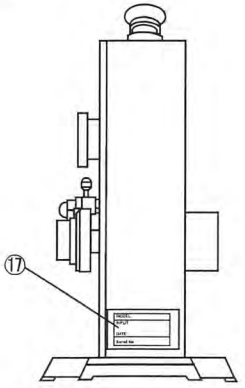


Figure 4-3

⑮ Measurement knob

Turn the measurement knob to set the boundary line appearing in the field of refraction view to the cross hairs. Interlocking with the measurement knob, the scale indicates the refractive index or Brix percent of the sample. The measurement knob has a double structure, namely it is composed of one inner knob and one outer ring; the inner knob is used for coarse adjustment while the outer ring is used for fine adjustment. Use the two appropriately for the occasion.

⑯ Illuminator lamp cable plug

Insertion terminal for the illuminator lamp cable connector.

⑰ Rating label

The serial number and ratings of the refractometer are shown on this label.

(2) Digital thermometer (Figure 4-4 · 4-5)

① Illumination selector switch

The light intensity can be selected from eight levels, and also the light intensity of the scale view can be selected from three levels with these switches (UP and DOWN).

② Main power switch

Turn this switch ON and the refractometer and the digital thermometer are turned on.

③ Main power connector port

Plug the AC power cable into this connector port.

④ Thermo-sensor cable connector port

Plug the thermo-sensor cable connector of the Abbe Refractometer into this connector port.

⑤ Lamp cable connector port

Plug the lamp cable connector of the Abbe Refractometer into this connector port.

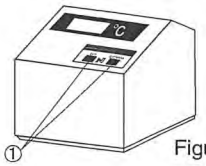


Figure 4-4

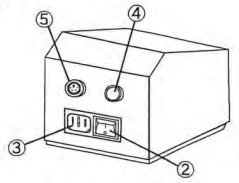


Figure 4-5

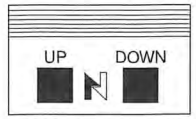
(3) How to use Illuminator Selector Switch

3-1. How to select the light intensity (from eight levels)

① Digital thermometer displays the level of the light intensity (0 to 7) by pressing UP or DOWN switch when the digital thermometer displays the current temperature.
*0 means the light is off.

② Press UP to get more intensity of the light, and press DOWN to get less intensity of the light.

③ After selecting the level of the light intensity, the digital thermometer displays the current temperature in 5 seconds Also, the digital thermometer displays the current temperature when the switchs are not operated for 5 seconds.



Illumination selector switch

3-2. How to select the light intensity of the scale view (from three levels)

① Press UP and DOWN switchs together when the digital thermometer displays the current temperature. The digital thermometer displays the level of the scale light intensity (C0 to C2).

② By pressing UP or DOWN, the display changes to C0, C1 or C2, and the scale light intensity changes. *C0 means the scale light is off.

③ After selecting the level of the scale view light intensity, the digital thermometer displays the current temperature in 5 seconds. Also the digital thermometer displays the current temperature when the switches are not operated for 5 seconds.

●About error messages●

The unit displays error messages when there is some problems or the unit is operated wrong.
「EEE」 ··· is displayed when the temperature sensor cable is not connected, or the unit does not work properly.
「LLL」 ··· is displayed when the temperature gets below 0°C.
When you can not specify the problem with the information above, please contact your ATAGO distributor.

5. Preparation for measurement

(1) Preparation of refractometer

① Set the refractometer with the prism unit in the front on a workbench or proper table (Figure 5-2).

② Plug the thermo-sensor cable connector into the thermo-sensor cable connector port on the real panel of the digital thermometer (Refer to ④ on P.13).

③ Connect one end of the illuminator lamp cable to the terminal on the right-hand side of the refractometer's main unit (Refer to ⑯ on P.10), and the other end to the back of the digital thermometer (Refer to ⑤ on P.13), as shown in Figure 5-1.

④ Plug the AC power cable into the AC cable terminal on the back of the digital thermometer.

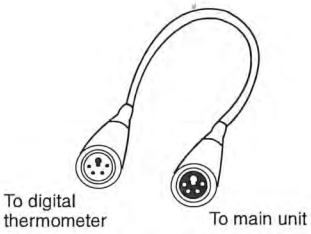


Figure 5-1

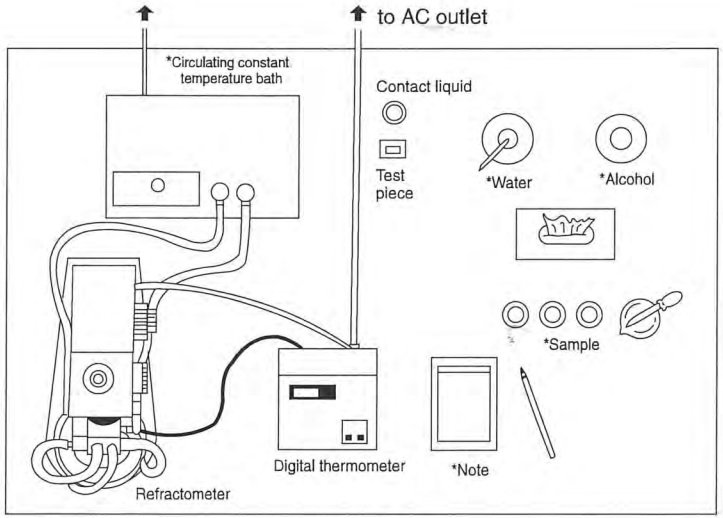


Figure 5-2

Note : The articles marked with asterisk (*) are not supplied as accessories to NAR-3T.

(2) Connection with circulating constant temperature bath

⚠ WARNING

◇ Pay careful attention to hot circulating water.
◇ For connecting a circulating constant temperature bath with the refractometer, make sure to use the elicon tube (made of vinyl chloride).
Moreover, tightly fasten each joint part between the nozzle and tube with the tube band.
◇ If the tube is damaged, replace it with new one as immediately as possible.
If the damaged tube is continuously used, the operator may scald himself with hot circulating water.
◇ The temperature of hot water to be supplied from a circulating constant temperature bath to this refractometer is limited to 50°C, and the flow rate of the circulating constant temperature bath should be 10 L/min. at maximum through a nozzle of 6mm caliber.
Too much discharge not only increases water pressure but also may cause disconnection between the nozzle and tube or may overload the water channel inside the refractometer.

Refractive indices of liquid matters vary depending on the temperature. Therefore, it is strongly recommended to use a circulating constant temperature bath together with the Abbe Refractometer for stable measurement at a constant measurement temperature as well as for obtaining possibly correct results.
There are water circulating channels provided by the main and secondary prisms, and constant temperature water is carried through tubes connected with the four nozzles shown in Figure 5-3.
The following explains the method to connect the Abbe Refractometer with the circulating constant temperature bath.

Note: Use Elicon tube (made of vinyl chloride) whose outer diameter is 12 to 13mm and inner diameter is 6 to 7mm.

① Prepare three pieces of tubes (A, B, C) for connection with a circulating constant temperature bath as specified below.
Tube A and Tube C : 90cm long each
Tube B : 20cm long

② Connect the tube A and tube C to the water outlet and inlet of the circulating constant temperature bath, and fasten them with tie bands.

③ Connect the other end of the tube A connected to the water outlet of the circulating constant temperature bath to the IN1 nozzle of the refractometer. Next, connect the nozzles IN2 and OUT1 with the tube B of 20cm long. Lastly, connect the other end of the tube C connected to the water inlet of the circulating constant temperature bath to the nozzle OUT2. Fasten every joint with a tie band.

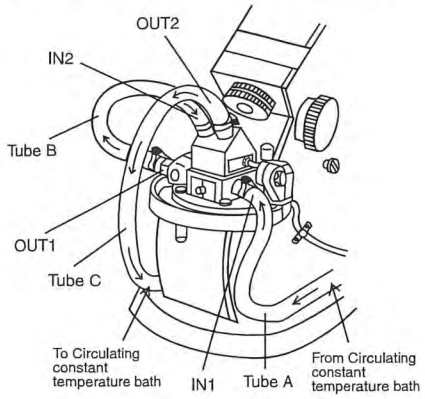


Figure 5-3

5. Preparation for measurement

④ Use of tie band (Figure 5-4).

Fasten each tie with the tie band according to the following procedure.



Figure 5-4

④-1 Insert an end of tube onto the nozzle so that the tube is tightly put on the nozzle.

④-2 To fasten the tube with the tie band, insert the tip of the tie band into the slot (Figure 5-5).

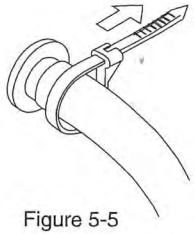


Figure 5-5

④-3 While holding the tie band by the part A, pull the tip (B) of the tie band to tighten it (Figure 5-6).

④-4 After tightening the tie band, cut the tie band by the part C for cutting off the extra (Figure 5-7).

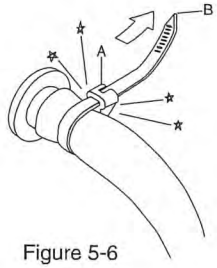


Figure 5-6

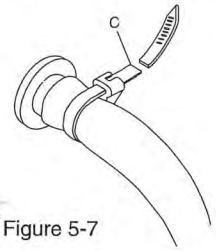


Figure 5-7

The tie band that were tightened once cannot be reused. For removing the tie band from the tube, cut it.

For fastening the tube with a tie band again, use a new tie band.

Tie bands can be ordered through your ATAGO Distributor (refer to page 37).

Reference temperature of circulating constant temperature bath

When the circulating constant temperature bath is used, there is a difference in temperature indication between the circulating constant temperature bath and the refractometer. This is a usual phenomenon and comes from the ambient temperature that affects not only the temperature of water flowing from the bath to the refractometer but also that of the refractometer itself. Therefore, the temperature of the prism is balanced with that of the water in the bath at a degree slightly higher than the water in the bath. Check the difference in temperature between the two and adjust the setting temperature of the circulating constant temperature bath so that the refractometer is constantly kept at desired temperature.

6. Power-on

⚠ WARNING

◇ Be sure to use the power cable accompanying the main unit.
◇ Do not plug the power cable into any electrical outlet other than AC100 to 240V.
◇ Do not use a power cable that is cut, damaged or processed.

⚠ CAUTION

◇ Plug the AC power cable into an indoor AC100 to 240V power outlet.

(1) Things to be checked before turning on the power.

①Make sure the power cable is plugged into the digital thermometer.

②Make sure the illuminator lamp cable is connected properly into the main unit of the refractometer and the digital thermometer.

③When using a circulating constant temperature bath, make sure it is connected.

※ The brightness of the illuminator lamps in the refraction field and the scale field can be adjusted using the brightness adjustment switch on the upper surface of the digital thermometer (refer to P.13).

(2) Power on

①Plug the power cable of the digital thermometer in an AC100 to 240V electrical outlet and ensure that the ground pin is connected as well.

②Turn on the power switch of the digital thermometer. The current temperature of the Abbe refractometer's prism will be displayed on the digital thermometer.

③The sample illuminator lamp and the scale field illuminator lamp of the Abbe refractometer will light up.

Contact the dealer or our distributor when the refractometer fails to function properly during measurement or check up. In such a case, turn off the power switch immediately, and then unplug the power cable.

7. Calibration (Scale adjustment)

⚠ CAUTION

- Don't wet the refractometer except the prism surface with water or sample liquid unreasonably. If the refractometer gets wet excessively, it may cause malfunction and breakdown of the refractometer.
- Don't tap or pick at the prism surface with a metal spoon, tweezers, etc. because the prism surface is made of optical glass.
  If the prism surface is scratched, the refractometer may fall in measurement.

There are two different methods for calibrating the refractometer scale as mentioned below.

Method ①: Calibration with distilled water
When measuring liquid sample in main, calibrate the scale in this method.

Method ②: Calibration with test piece
When measuring solid sample in main, calibrate the scale in this method.

(1) Calibration with distilled water

① Turn the prism open/shut handle to open the secondary prism. After wiping down the main and secondary prism surface, drip a small amount of distilled water on it. Gently close the secondary prism (Figure 7-1).

② Connect the refractometer with the circulating constant temperature bath, and set the measurement temperature (temperature indication of the digital thermometer) to 20℃.
While observing through the eyepiece, turn the measurement knob to get the refractive index scale to indicate approximately 1.3330 and the Brix percent scale to indicate approximately 0.0% (the upper scale is for reading refractive index while the lower scale is for Brix percent). When the temperature is other than 20℃, the scale must read the refractive index at the actual temperature and Brix 0.0%.

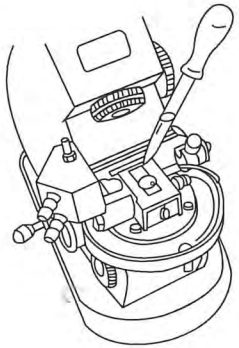


Figure 7-1

③ Seeing the field of refraction view, the colored boundary line is observed near the intersection of the cross hairs. Turn the color compensator knob to achromatize the boundary line, and stop turning when the boundary line becomes neither reddish nor bluish. Since reddish edge appears just above the boundary line while bluish edge appears just below it, the midpoint where neither reddish edge nor bluish edge appears indicates that the color is completely compensated.

④ Turn the measurement knob to set the boundary line to the intersection of the cross hairs. Then remove the cap of the calibration section by turning it counterclockwise, and adjust the calibration screw located in the center of the calibration section with the Allen wrench supplied as an accessory so that the refractive index scale reads 1.3330 at 20℃ of measurement temperature.

Note: When the measurement temperature is other than 20℃, adjust the scale indication to correspond to the refractive index at the actual measurement temperature referring to the following table.

Relation between temperature and refractive index (nD)

Temperature ℃	Refractive index nD	Temperature ℃	Refractive index nD
10	1.33369	26	1.33240
11	1.33364	27	1.33229
12	1.33358	28	1.33217
13	1.33352	29	1.33206
14	1.33346	30	1.33194
15	1.33339	31	1.33182
16	1.33331	32	1.33170
17	1.33324	33	1.33157
18	1.33316	34	1.33144
19	1.33307	35	1.33131
20	1.33299	36	1.33117
21	1.33290	37	1.33104
22	1.33280	38	1.33090
23	1.33271	39	1.33075
24	1.33261	40	1.33061
25	1.33250		

(2) Calibration with test piece

The test piece and monobromonaphthalene which are supplied as accessories to the refractometer are used for this calibration method.

① Turn down the prism open/shut handle ③-a (see to P.10 Fig.4-2) to the front side to raise the secondary prism, and then turn the handle ③-b (see to P.10 Fig.4-1) leftwards to open the secondary prism completely. Next, turn the knob of the reflector for solid sample measurement counterclockwise to release the reflector, and pull the knob to the front side to raise the reflector upwards. After raising the reflector, turn the knob clockwise to fasten the reflector (Figure 7-2).

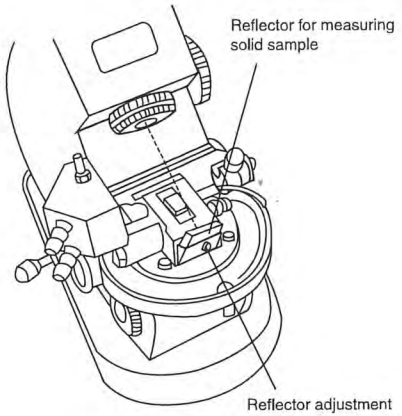


Figure 7-2

② After wiping down the surface of the main prism and test piece, apply a very small amount of monobromonaphthalene on the major polished side (the side without indication of the refractive index, see Figure 7-3) of the test piece. If monobromonaphthalene is applied too much, it may cause error in calibration and result in incorrect measurement.
Proper amount of monobromonaphthalene is one drop of 1mm in diameter.

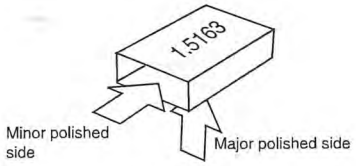


Figure 7-3

③ Contact the major polished side of the test piece evenly to the center part of the main prism surface. At that time, set the test piece so that its minor polished side faces the reflactor. With contact of the test piece to the main prism, monobromonaphthalene spreads between the test piece and main prism as a thin film. If monobromonaphthalene spreads out of the test piece, the amount is too much. On the other hand, if it dose not spread for the whole test piece, the amount is too small. Don't press the test piece to the main prism with fingers, etc. If there is dust or foreign substance between them, it may not only result in incorrect calibration but also damage the main prism surface.

④ If the test piece fails in close contact with the prism surface, remove it once and again try to do same work after carefully cleaning both the surfaces of the test piece and the main prism with tissue moistened with alcohol.

⑤ Reflect the light of lamp for the sample illuminator on the reflector and receive it through the minor polished side of the test piece.

⑥ While observing through the eyepiece, gently turn the measurement knob to set the scale indication approximately to the refractive index shown on the test piece (the upper scale is for reading refractive index from 1.3000 to 1.7100, while the lower scale is for Brix percent from 0.0 to 95.0%) (Figure 7-4).

⑦ Seeing the field of refraction view, the colored boundary line is observed near the intersection of the cross hairs. Turn the color compensator knob to achromatize the boundary line, and stop turning when the boundary line becomes neither reddish nor bluish. Since reddish edge appears just above the boundary line while bluish edge appears just below it, the midpoint where neither reddish edge nor bluish edge appears indicates that the color is completely compensated.

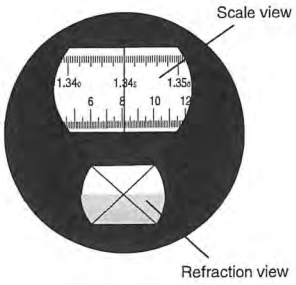


Figure 7-4

When you have a difficulty seeing the boundary line clearly because of hair-line reflection, place a white paper on the refractor to let the light reflect from it so that the light can go through the lighting side of the sample.

7. Calibration (Scale adjustment)

⑧ Turn the measurement knob to set the boundary line to the intersection of the cross hairs. Then, remove the cap of the calibration section by turning it counterclockwise, and adjust the calibration screw located in the center of the calibration section with the Allen wrench supplied as an accessory so that the scale indication is set to the refractive index appearing on the test piece (Figure.7-5).

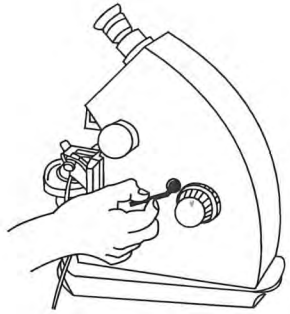


Figure 7-5

⑨ Remove the test piece and clean the surface of both the main prism and test piece with alcohol, etc. Set the test piece on the main prism for measuring it again and check to see if the measured value is equal to the known refractive index of the test piece.

※ The brightness of the illuminator lamps in the refraction field and the scale field can be adjusted using the brightness adjustment switch on the upper surface of the digital thermometer (See P.13).

● Cautions on use of monobromonaphthalene

Since monobromonaphthalene is very corrosive liquid, wipe it off put of the test piece and prism surface with gauze or tissues moistened with alcohol immediately after calibration is complete. If there is a very small amount of monobromonaphthalene left on the main prism, the prism surface is seriously stained within 24 hours and the prism may become incapable of measurement with unclear boundary line. If it is left for a considerably long time, the prism becomes useless. Such stain results from minute corrosion on the prism surface. At a glance the prism surface looks clean, but it is actually stained in rainbow-color or faintly clouded, which can be seen when it is observed at a low angle. If such the surface is observed in magnification, it is uneven because of minute corrosions. Such corroded surface is worse than the surface having one or two scratches.

When handing monobromonaphthalene, pay careful attention to its highly corrosive characteristic and carefully clean the applied area after use.

The Safety Data Sheet (SDS) for monobromonaphthalene says that it may irritate the skin and the eyes. Although the harmful effect of monobromonaphthalene is not likely to occur under the ordinary circumstances as the amount used in one measurement is less than 0.1ml, be sure to wear gloves and masks and take other safety measures with due caution when measuring a sample.

8. Measurement of liquid sample

⚠ WARNING

- When using this instrument for measuring matters harmful to humans, very carefully do it with gloves and proper mask as well as with a good knowledge of the characters of the matters.
- When the refractometer smells nastily, smokes or is overheated, immediately turn it off with the power switch and unplug the power cable from the outlet.
  If the refractometer is continuously operated in such a condition, it may cause a fire or damage to the refractometer. In such a case, ask the dealer or our distributor to inspect the refractometer as well as to investigate the cause.

⚠ CAUTION

- Don't wet the refractometer except the prism surface with water or sample liquid unreasonably. If the refractometer gets wet excessively, it may cause malfunction and breakdown of the refractometer.
- Don't tap or pick at the prism surface with a metal spoon, tweezers, etc. because the prism surface is made of optical glass.
  If the prism surface is scratched, the refractometer may fall in measurement.
- When measurement is complete, wipe up sample from the prism surface and its surroudings with soft tissue moisted with water first, and then wipe the wet parts with dry tissue to dry them up.
- After measurement of a sample of a high molecular compound, oil and fat, etc., wipe the prism surface with tissues moistened with alcohol or neutral detergent first and then wipe it up again with dry tissue to dry up.
- On ending a day's measurement, turn off the power switch.
- When transporting the refractometer, make sure to put it in the carton case which the refractometer was initially contained in.

① Open the secondary prism and drip 2 or 3 drops sample liquid onto the center part of the main prism surface (Figure 8-1). Then, gently close the secondary prism. The sample spreads between the main prism and secondary prism as a thin film.

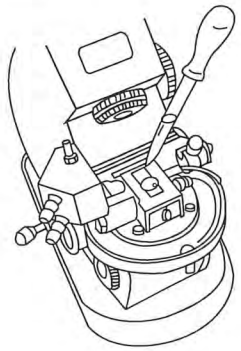


Figure 8-1

8. Measurement of liquid sample

② While observing through the eyepiece, gently turn the measurement knob until the boundary line appears in the field of refraction view. At that time, the boundary line may be colored and unclear because it is not yet achromatized. If so, turn the measurement knob in a wide range so as to set it at a point where the field of refraction view cleary changes from bright field to dark field or vice versa. The brightness of the field can be adjusted with the illumination selector switch in the upper part of the digital thermometer, which can be set to one of 8 steps.

※ The brightness of the illuminator lamps can be adjusted using the brightness adjustment switch on the upper surface of the digital thermometer (See P.13).

③ Turn the color compensator knob to achromatize the boundary line so as to get it to appear clearly in the field. Again turn the measurement knob to set the boundary line to the intersection of the cross hairs.

④ The upper scale is for reading refractive index (nD) while the lower scale is for Brix percent. Since the minimal graduation unit for refractive index is 0.0002, the scale can be read at a unit of 0.00005 with the eye. On the other hand, Brix percent scale is graduated at a unit of 0.1%, the scale can be read at a unit of 0.01% with the eye.

● **Caution on measurement of liquid sample**

Since measured value for liquid sample changes depending on change of temperature, it is advised to use a circulating constant temperature bath to keep the sample temperature constant. If liquid sample is measured without use of a circulating constant temperature bath, read the temperature indication to know the actual measurement temperature and append it to measured value without fail.

9. Measurement of solid sample

⚠ CAUTION

After measurement finishes, wipe up wet and soiled parts of the instrument with tissues moistened with alcohol or neutral detergent. Moreover, wipe down the whole instrument with dry tissues to remove moisture completely from it.

For measuring solid samples, use contact liquid, the test piece set or/and polarizing eyepiece depending on the situation. If the occasion arises, inquire of the store that you purchased your refractometer from or our distributor for those items referring to the parts and consumable supplies list on page 37.
Measurable solid samples are limited to transparent matters such as glass, plastic. Generally measurement of solid samples such as glass, etc. has no need of a constant temperature circulating bath, because their refractive indices are hardly affected by temperature change. However, some kinds of plastics whose refractive indices are greatly affected by temperature change need to use a constant temperature circulating bath.

(1) Desirable shape of solid sample

Rectangular parallelepipeds of 20 to 30mm long by 8mm bread by 3 to 10mm high are optimum. It is desired that the lighting side and the surface to contact the main prism are polished (if not finished with optical polish but the surface is plane and shiny, it has no problem) and the edge between lighting side and the surface to contact the main prism meet at right angles to each other (Figure 9-1).

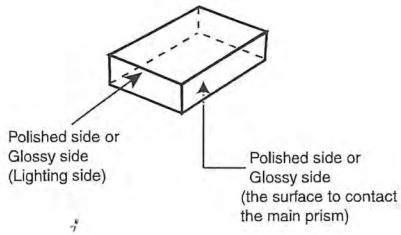


Figure 9-1

(2) Measuring method of solid sample

① Open the secondary prism completely and apply a small amount of contact liquid onto the surface to contact the main prism of the sample. Put the sample with the side on which contact liquid is applied facing down on the main prism.

9. Measurement of solid sample

② Turn the knob of the reflector for solid sample measurement counterclockwise to release the reflector, and pull the knob to the front side to raise the reflector upwards. Turn the knob clockwise again to fasten the reflector as it is raised. Reflect the light of lamp for the sample illuminator on the reflector and receive it through the lighting side of the sample (Figure 9-2).

③ In the same manner as liquid sample measurement, operate the refractometer and read the scale.

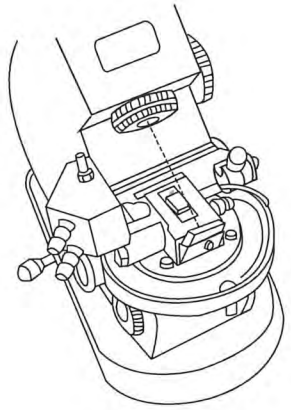


Figure 9-2

(3) Contact liquid to be used for solid sample measurement

For measuring a solid sample, it is required to use contact liquid proper to the sample to make close contact between the sample and the prism. The refractive index of contact liquid must be higher than that of the sample.
For example, the following solutions are generally used as contact liquids.

Methyl salicylate $n_D^{20} \fallingdotseq 1.53$
Monobromonaphthalene $n_D^{20} \fallingdotseq 1.65$
Methylene iodide $n_D^{20} \fallingdotseq 1.73$
Methylene iodide containing sulfur solution $n_D^{20} \fallingdotseq 1.74$ to 1.78 (depending on sulfur concentration)

Since all of the above-mentioned solutions have the highly corrosive characteristic, choose a proper solution that is comparatively weak in corroding the sample.

When you have a difficulty seeing the boundary line clearly because of hair-line reflection, place a white paper on the refractor to let the light reflect from it so that the light can go through the lighting side of the sample.

10. Measurement of powdered sample

⚠ CAUTION

After measurement finishes, wipe up wet and soiled parts of the instrument with tissues moistened with alcohol or neutral detergent. Moreover, wipe down the whole instrument with dry tissue to remove moisture completely from it.

Refractive indices of powdered samples shall be measured by such an indirect method as mentioned below because it is impossible to measure them directly. Sample matters that can be measured in the following way are transparent powders such as glass powder, powdered clear ores (quartz, crystal, some gem stones), etc.

①This method requires to use two different kinds of clear liquids whose refractive indices (assume that they are n1 and n2 respectively) are different from each other. Moreover, it is expected that n1 and n2 are respectively higher and lower than the refractive index of the powdered sample to be measured.

②Regarding the chemical characteristics of the two liquids, they must well be mixed in each other without reaction and the mixture must prevent the powdered sample from dissolving in it.

③After taking a small amount the powdered sample in a clean test tube, pour about 1ml of a liquid (n1) into it. The powered sample mixed in the liquid is seen whitish.

④Carefully pour the other liquid (n2) into the test tube little by little while mixing it well in the former liquid. The powdered sample becomes invisible in a short time because the refractive indices of the powdered sample and the mixture correspond to each other.
As soon as the powdered sample is invisible, stop pouring the second liquid and measure the mixture for the refractive index. Therefore the refractive index of the powdered sample can be known because it is equivalent to that of the mixture.

10. Measurement of powdered sample

● **Principle of measurement of powder's refractive index and cautions on measurement**

When powder is mixed in liquid, if the refractive indices of the powder and the liquid are different from each other, there occurs irregular reflection on the powder surface and the powder can accordingly be recognized by the eye (Figure 10-1). If the powder and the liquid become equivalent in the refractive index to each other, irregular reflection on the powder surface is eliminated and the test tube looks containing the liquid only (Figure 10-2). The principle of this phenomenon is applied to the measurement of powdered sample.
However, if the powdered sample is observed by this method in the daylight, it does not become invisible but is seen like colored because the point that refractive indices of the powder and the liquid varies depending on the wavelength of the daylight. In such a case, use of a light source having a constant wavelength such as D-line of a sodium lamp solves the problem and measurement with such a light source can accurately be carried out.

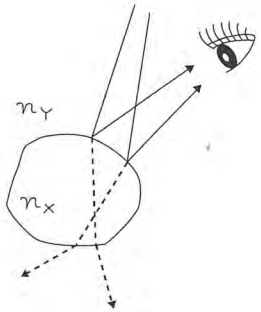


Figure 10-1

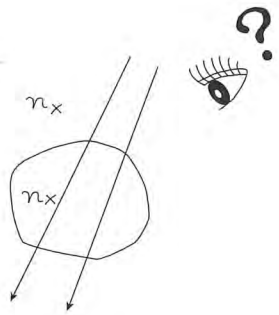


Figure 10-2

Note: Besides the above-mentioned method, the "microscopic dipping measurement (Becke line test)" is applied to measure-ment of refractive index of the powdered sample.

11. Situations that may require additional attention

(1) Dewing on the back of main prism

① In the hottest season, the field of refraction view occasionally becomes invisible during measurement with a refractometer whose prism unit temperature is constantly controlled at 20℃ with circulating water. When the atmospheric temperature and humidity are considerably high, circulating water whose temperature is controlled at 20 ℃ causes the refractometer to dew inside, particularly the back side of the main prism. Although this phenomenon seldom occurs, pay heed to dewing inside the refractometer in extremely hot, cold, and high humid seasons.

② To settle this trouble if it occurs, turn the cap of the air nozzle section counterclockwise to remove it and then connect the air purger (RE-1395) supplied to the nozzle. Ventilate the inside of the refractometer with the air purger to evaporate dew drops and moisture.

③ When a plenty of dew drops have accumulated inside, it takes a considerably long time to dehumidify the refractometer. Therefore, always pay heed to the color of desiccant tablets (blue color of cobalt chloride turns into red when it becomes moist) inside the desiccant case. Desiccant has no need of frequent replacement because of the high airtight structure of the refractometer, but requires frequent check.

(2) Discoloration or "Burning" of the main prism

Discoloration or burning may appear on the main prism as a result of a chemical reaction or prolonged exposure to high temperature samples. The discoloration appears as a slightly blue-purple layer or "rainbow" effect.
This damage may cause a blurry field of vision, making it difficult to see the boundary line. Light discoloration may be removed by the Prism Polishing Powder provided.

①Stir water into the Prism Polishing Powder to make a smooth paste.

②Using a cotton swab, applying light pressure, rub the paste with an up and down motion (non-circular) on the main prism surface. Check the progress after about 20 to 30 strokes. If discoloration is still visible, repeat the process with another 20 to 30 strokes to remove remaining discoloration.

Heavily discolored surfaces may not be removed with this method. Please contact your ATAGO distributor.

(3) Measurement method of pasty sample

① The harder a sample is, the more difficult measurement is. Because, the gap between the main prism and secondary prism is widened with increase of sample's hardness, and lighting accordingly becomes worse. When measuring pasty sample, spread it on the main prism surface as thin as possible with a spatula or the like so that the gap between the two prisms becomes small.

② It is much more difficult to measure a pasty sample containing different materials that are kneaded or tempered together; such as peanut butter, bean jam, unclear oily samples, and other insoluble pasty samples. For measuring such pasty samples, it is advised to try to mix the ingredients as completely as possible and slightly heat the sample approximately to 40°C to soften it for carrying out measurement more easily.

(4) For measuring liquid sample containing insoluble solids

(Simultaneous analysis of insoluble solids, sugar and water)

①When solution containing insoluble solids is measured for refractive index, only the refractive index of the solution except the insoluble solids is measured. For example, assume that sweetened and jellied bean paste is measured and the refractometer reads Brix70% for it. If the sample of the sweetened and jellied bean paste contains bean jam at a rate of 20% in weight, the Brix value of the whole sample is regarded as 56%. Explaining in detail, if weight of the sweetened and jellied bean paste is 100g, the weight of insoluble ingredient(s) is 20g, weight of sugar is 56g and that of water is 24g. The total weight of the solution excluding the insoluble ingredients is 80g, which includes 56g of sugar besides 24g of water. Therefore, the refractometer reads the sugar content of solution as Brix70%.

②As the above example suggests, samples containing much insoluble ingredients require the most careful attention to the measured values.

③Simultaneous analysis of solids, sugar and water contained in bean jam.

a. Directly measure a sample of bean jam for Brix(%) and note the measured value as "A".
b. Mash and knead the bean jam well, and dissolve it in water of the same weight well. Measure this solution for Brix(%) and note down the measured value as "B".
c. With known "A" and "B" calculate the weight percent of insoluble solids, sugar and water respectively according to the following equations.

● Weight percent of insoluble solids:

$$100\left(1-\frac{B}{A-B}\right)\%$$

● Weight percent of sugar:

$$\frac{AB}{A-B}\ \%$$

● Weight percent of water:

$$\frac{B(100-A)}{A-B}\ \%$$

12. Finding average dispersion value and Abbe number

(1) Dispersion value

Refractive index varies depending on color (wavelength) of the light. Therefore, the Abbe Refractometer uses D-line (wavelength is 589.3nm, orange color) as the standard light source for carrying out measurements stably and accurately. Dispersion value means the degree that a refractive index changes with other light sources of difference wavelengths, and it is expressed in an average dispersion value (nF-nC), where nF-nC is a difference between the refractive index with F-line (486.1nm) and that with C-line (656.3nm).

If the peculiar value of nF-nC of a substance is known, it greatly helps to know the characteristic of the substance, because the nF-nC of a substance is determined by its molecular structure.

As a simple example, assume that there are two liquids that are completely different in quality from each other but the same in refractive index (nD). The two liquids cannot be discriminated from each other by the refractive index, but can be discrimineted by the average dispersion value which is different from each other. Therefore, dispersion value is very useful to identify unknown substances.

The Abbe Refractometer NAR-3T is capable of measuring average dispersion value (nF-nC). For details, refer to page 32.

However, the NAR-3T is incapable of measuring refractive index with other light sources of different wavelengths such as nF and nC.

Note:
When measuring a sample to calculate the Abbe value, be sure to use the natural light (white light) instead of the accompanying illuminator lamp (orange light).

(2) Finding average dispersion value

Dispersion value (nF-nC) can be found according to the following equation.

$$nF - nC = A + B\alpha$$

In the above equation, values A and B can simply be found out of Table 1 on page 34 by checking up values corresponding to a measured refractive index on the table after measuring the sample.
To obtain a value α, achromatize the boundary line by turning the color compensator knob and read the scale indication (Z) on the knob at the time. A value α can simply be found out of Table 2 on page 35 by checking up a value α corresponding to the value Z on the table.

(3) Finding Abbe number

Abbe number can be obtained by calculation with the following equation.

where,

$$\nu = \frac{nD-1}{nF-nC}$$

ν = Abbe number
nD = Refractive index
nF−nC = Dispersion value

(4) Example of measurement

Refractive index (nD)=1.4827	
Reading of dispersion scale	
Left	Right
42.3	42.2
42.2	42.1
42.2	42.3
42.2	42.2
42.2	42.2
Average reading for right and left (Z)=42.2	

Z=42.2
A=0.02336
B=0.02774
$\alpha = -0.596$
$B\alpha = -0.01653$
$nF - nC = A + B\alpha = 0.00683$

$$\nu = \frac{nD - 1}{nF - nC} = \frac{0.4827}{0.00683} = 70.7$$

(5) Finding values A and B more accurately

[Example] Assuming that nD (refractive index) = 1.4827;
look up in the column A for a value corresponding to 1.48 in the nD column of Table 1, and there is 0.02337 found as the objective value.
0.02337.....(a)
In the same manner, − 2 is found in the Difference column.
When (a) and − 2 are applied to the following equation, calculation is carried as:
$27 \times (-2) \times 10^{-7} = -0.0000054$.....(b)
Therefore,
$A = a + b \fallingdotseq 0.02336$
Carry out the same calculation for a value of B.

(6) Finding value α more accurately

Turn the color compensator knob clockwise until the boundary line is achromatized, and read the indication of the dispersion scale at the time. Next, turn the color compensator knob counterclockwise until the boundary line is achromatized, and read the dispersion scale indication at that time. Alternately repeat the above-mentioned operations several times and calculate an average value (Z) of the several measurement results.
With the obtained value (Z), find the value of a on Table 2 on page 35.

Calculation method for reference

$A = 0.02337 + (-2) \times 27 \times 10^{-7}$
$= 0.02337 - 54 \times 10^{-7}$
$= 0.02337 - 0.0000054$
$\fallingdotseq \underline{0.02336}$

$B = 0.02786 + (-46) \times 27 \times 10^{-7}$
$= 0.02786 - 1215 \times 10^{-7}$
$= 0.02786 - 0.0001215$
$\fallingdotseq \underline{0.02774}$

$\alpha = -0.596$
$B\alpha = 0.02798 \times (-0.596) = -0.01653304$
$\fallingdotseq \underline{-0.01653}$

$A + B\alpha = 0.02774 - 0.01653 = 0.00683$

$$\nu = \frac{nD-1}{nF-nC} = \frac{0.4827}{0.00683} = 70.7$$

12. Finding average dispersion value and Abbe number

Table 1 Relation between nD and A,B

nD	A	Difference	nD	B	Difference
1.30	0.02407		1.30	0.03291	
1.31	0.02402	−5	1.31	0.03277	−14
1.32	0.02397	−5	1.32	0.03261	−16
1.33	0.02392	−5	1.33	0.03244	−17
1.34	0.02387	−5	1.34	0.03225	−19
1.35	0.02382	−5	1.35	0.03205	−20
1.36	0.02377	−5	1.36	0.03183	−22
1.37	0.02373	−4	1.37	0.03159	−24
1.38	0.02369	−4	1.38	0.03134	−25
1.39	0.02365	−4	1.39	0.03107	−27
1.40	0.02361	−4	1.40	0.03078	−29
1.41	0.02357	−4	1.41	0.03048	−30
1.42	0.02353	−4	1.42	0.03016	−32
1.43	0.02350	−3	1.43	0.02982	−34
1.44	0.02347	−3	1.44	0.02946	−36
1.45	0.02344	−3	1.45	0.02909	−37
1.46	0.02341	−3	1.46	0.02870	−39
1.47	0.02339	−2	1.47	0.02829	−41
1.48	0.02337	−2	1.48	0.02786	−43
1.49	0.02335	−2	1.49	0.02741	−45
1.50	0.02333	−2	1.50	0.02693	−48
1.51	0.02332	−1	1.51	0.02644	−49
1.52	0.02331	−1	1.52	0.02592	−52
1.53	0.02330	−1	1.53	0.02539	−53
1.54	0.02329	−1	1.54	0.02482	−57
1.55	0.02329	0	1.55	0.02424	−58
1.56	0.02329	0	1.56	0.02362	−62
1.57	0.02330	+1	1.57	0.02298	−64
1.58	0.02331	+1	1.58	0.02230	−68
1.59	0.02332	+1	1.59	0.02160	−70
1.60	0.02334	+2	1.60	0.02086	−74
1.61	0.02337	+3	1.61	0.02008	−78
1.62	0.02340	+3	1.62	0.01927	−81
1.63	0.02344	+4	1.63	0.01841	−86
1.64	0.02349	+5	1.64	0.01750	−91
1.65	0.02355	+6	1.65	0.01654	−96
1.66	0.02362	+7	1.66	0.01551	−103
1.67	0.02370	+8	1.67	0.01441	−110
1.68	0.02380	+10	1.68	0.01323	−118
1.69	0.02393	+13	1.69	0.01195	−128
1.70	0.02408	+15	1.70	0.01053	−142

Constants
ω=63° 0'
2k=183' 26"
nD=1.73984
nF−nC=0.02613

Table 2 Relation between Z and α Z = Scale indication of the color compensator knob

Z	α	Z	α	Z	α	Z	α	Z	α	Z	α
30.0	−0.000	35.0	−0.259	40.0	−0.500	45.0	−0.707	50.0	−0.866	55.0	−0.966
30.1	−0.005	35.1	−0.264	40.1	−0.505	45.1	−0.711	50.1	−0.869	55.1	−0.967
30.2	−0.010	35.2	−0.269	40.2	−0.509	45.2	−0.714	50.2	−0.871	55.2	−0.969
30.3	−0.016	35.3	−0.274	40.3	−0.514	45.3	−0.718	50.3	−0.874	55.3	−0.970
30.4	−0.021	35.4	−0.279	40.4	−0.518	45.4	−0.722	50.4	−0.876	55.4	−0.971
30.5	−0.026	35.5	−0.284	40.5	−0.522	45.5	−0.725	50.5	−0.879	55.5	−0.972
30.6	−0.031	35.6	−0.289	40.6	−0.527	45.6	−0.729	50.6	−0.881	55.6	−0.974
30.7	−0.037	35.7	−0.294	40.7	−0.531	45.7	−0.733	50.7	−0.884	55.7	−0.975
30.8	−0.042	35.8	−0.299	40.8	−0.536	45.8	−0.736	50.8	−0.886	55.8	−0.976
30.9	−0.047	35.9	−0.304	40.9	−0.540	45.9	−0.740	50.9	−0.889	55.9	−0.977
31.0	−0.052	36.0	−0.309	41.0	−0.545	46.0	−0.743	51.0	−0.891	56.0	−0.978
31.1	−0.058	36.1	−0.314	41.1	−0.549	46.1	−0.747	51.1	−0.893	56.1	−0.979
31.2	−0.063	36.2	−0.319	41.2	−0.553	46.2	−0.750	51.2	−0.896	56.2	−0.980
31.3	−0.068	36.3	−0.324	41.3	−0.558	46.3	−0.754	51.3	−0.898	56.3	−0.981
31.4	−0.073	36.4	−0.329	41.4	−0.562	46.4	−0.757	51.4	−0.900	56.4	−0.982
31.5	−0.078	36.5	−0.334	41.5	−0.566	46.5	−0.760	51.5	−0.903	56.5	−0.983
31.6	−0.084	36.6	−0.339	41.6	−0.571	46.6	−0.764	51.6	−0.905	56.6	−0.984
31.7	−0.089	36.7	−0.344	41.7	−0.575	46.7	−0.767	51.7	−0.907	56.7	−0.985
31.8	−0.094	36.8	−0.349	41.8	−0.579	46.8	−0.771	51.8	−0.909	56.8	−0.986
31.9	−0.099	36.9	−0.353	41.9	−0.584	46.9	−0.774	51.9	−0.911	56.9	−0.987
32.0	−0.105	37.0	−0.358	42.0	−0.588	47.0	−0.777	52.0	−0.914	57.0	−0.988
32.1	−0.110	37.1	−0.363	42.1	−0.592	47.1	−0.780	52.1	−0.916	57.1	−0.989
32.2	−0.115	37.2	−0.368	42.2	−0.596	47.2	−0.784	52.2	−0.918	57.2	−0.989
32.3	−0.120	37.3	−0.373	42.3	−0.600	47.3	−0.787	52.3	−0.920	57.3	−0.990
32.4	−0.125	37.4	−0.378	42.4	−0.605	47.4	−0.790	52.4	−0.922	57.4	−0.991
32.5	−0.131	37.5	−0.383	42.5	−0.609	47.5	−0.793	52.5	−0.924	57.5	−0.991
32.6	−0.136	37.6	−0.388	42.6	−0.613	47.6	−0.797	52.6	−0.926	57.6	−0.992
32.7	−0.141	37.7	−0.392	42.7	−0.617	47.7	−0.800	52.7	−0.928	57.7	−0.993
32.8	−0.146	37.8	−0.397	42.8	−0.621	47.8	−0.803	52.8	−0.930	57.8	−0.993
32.9	−0.151	37.9	−0.402	42.9	−0.625	47.9	−0.806	52.9	−0.932	57.9	−0.994
33.0	−0.156	38.0	−0.407	43.0	−0.629	48.0	−0.809	53.0	−0.934	58.0	−0.995
33.1	−0.162	38.1	−0.412	43.1	−0.633	48.1	−0.812	53.1	−0.935	58.1	−0.995
33.2	−0.167	38.2	−0.416	43.2	−0.637	48.2	−0.815	53.2	−0.937	58.2	−0.996
33.3	−0.172	38.3	−0.421	43.3	−0.641	48.3	−0.818	53.3	−0.939	58.3	−0.996
33.4	−0.177	38.4	−0.426	43.4	−0.645	48.4	−0.821	53.4	−0.941	58.4	−0.996
33.5	−0.182	38.5	−0.431	43.5	−0.649	48.5	−0.824	53.5	−0.943	58.5	−0.997
33.6	−0.187	38.6	−0.435	43.6	−0.653	48.6	−0.827	53.6	−0.944	58.6	−0.997
33.7	−0.193	38.7	−0.440	43.7	−0.657	48.7	−0.830	53.7	−0.946	58.7	−0.998
33.8	−0.198	38.8	−0.445	43.8	−0.661	48.8	−0.833	53.8	−0.948	58.8	−0.998
33.9	−0.203	38.9	−0.449	43.9	−0.665	48.9	−0.836	53.9	−0.949	58.9	−0.998
34.0	−0.208	39.0	−0.454	44.0	−0.669	49.0	−0.839	54.0	−0.951	59.0	−0.999
34.1	−0.213	39.1	−0.459	44.1	−0.673	49.1	−0.842	54.1	−0.953	59.1	−0.999
34.2	−0.218	39.2	−0.463	44.2	−0.677	49.2	−0.844	54.2	−0.954	59.2	−0.999
34.3	−0.223	39.3	−0.468	44.3	−0.681	49.3	−0.847	54.3	−0.956	59.3	−0.999
34.4	−0.228	39.4	−0.473	44.4	−0.685	49.4	−0.850	54.4	−0.957	59.4	−1.000
34.5	−0.233	39.5	−0.477	44.5	−0.688	49.5	−0.853	54.5	−0.959	59.5	−1.000
34.6	−0.239	39.6	−0.482	44.6	−0.692	49.6	−0.855	54.6	−0.960	59.6	−1.000
34.7	−0.244	39.7	−0.486	44.7	−0.696	49.7	−0.858	54.7	−0.962	59.7	−1.000
34.8	−0.249	39.8	−0.491	44.8	−0.700	49.8	−0.861	54.8	−0.963	59.8	−1.000
34.9	−0.254	39.9	−0.495	44.9	−0.703	49.9	−0.863	54.9	−0.965	59.9	−1.000
										60.0	−1.000

Note: When the scale of the color compensator knob indicates 0.00 to 30.0, α can be obtained by means of the following calculation and Table 2.

60.0 − (scale value of the color compensator knob) = Z

With the obtained Z, α can be found on Table 2. In this case, α is a positive number.

13. Cleaning and maintenance

(1) With completion of measurement, wipe the sample out of the prism surface and its periphery with soft tissues moistened with water. Then, wipe them up again with dry tissues to remove moisture completely.

(2) After measurement of a macro-molecular or oily sample, wipe down the prism surface and its periphery with soft tissues moistened with alcohol or neutral detergent. Then, wipe them up again with dry tissues to remove moisture completely.

(3) If the eyepiece lens has been soiled, wipe it down with soft tissues moistened with a small amount of water.

(4) After cleaning, keep the refracto-meter with it in a dry place avoiding high humidity, dust and direct sunlight.

(5) When the refractometer is left in the measuring site as it is connected with a constant temperature circulating bath, wipe up not only the refractometer but also the workbench, and put the vinyl cover on the refractometer after straightening up everything on the workbench.
Moreover, make sure to cover the constant temperature circulating bath to avoid vaporization of water as well as to switch off the pump and all other instruments.

(6) For keeping the refractometer, it is recommended to insert dry tissues between the main prism and sacondary prism to protect their respective surfaces.

(7) Regarding tissues, make sure to use soft tissues and not to use perfumed ones. When using gauze for tissues, don't use new gauze but use washed one because its fiber is softened.

14. Replacement of consumable supplies and component parts

1. Consumable supplies and component parts to be supplied to users.

Part names and ratings of consumable supplies and component parts that will be supplied to users for replacement are as follows. If you need some, contact the dealer or our distributor.

Part Name	Part No.	Remarks
Main & secondary prism house for NAR-3T Assembled unit	RE-1306	
LED Lamp	RE-1172	
Thermo-sensor unit	RE-1359	
Desiccant	RE-1387	30g in pack
Test piece A	RE-1195	nD : 1.516(※), with monobromonaphthalene as contact liquid (for scale adjustment, measurement film)
Contact liquid - monobromonaphthalene	RE-1196	Approx. nD : 1.65, 4ml in bottle
Contact liquid - methylene iodide containing sulfur solution	RE-1199	Approx. nD : 1.78, 4ml in bottle
Tie band	RE-8507	Heat-resistant (up to 150°C) A set of 10 zip ties For water bath connection

※: The correct Refractive Index is on a test

2. Replacement of parts

(1) Prism

● **Since the 3T's main and secondary prisms are assembled in a unit, they will be replaced together as a unit of prism assembly.**

①Turn the measurement knob so that the scale reads 1.300 (nD) approximately to avoid disturbance of replacing work by the internal mirror.

Note: Be careful neither to touch nor to soil the internal mirror.

②Disconnect the thermo-sensor cable by pulling its connector out of the digital thermometer's connector jack.

③Open the secondary prism and remove the four screws A and B in alphabetical order. Use a phillips head (+) screwdriver to remove the screws A and B (Figure 14-1).

④Remove the four screws of the plate A with an Allen wrench (hexagon-headed key wrench) supplies with the instrument (Figure 14-2).

⑤Insert the head of the Allen wrench into the notch on the plate A. While using the wrench as a lever to raise the plate A, remove it together with the prism unit (Figure 14-3).

Note: If the sample stage is soiled in the part to be covered by the prism unit, wipe it down with soft tissues moistened with ethyl alcohol or neutral detergent.

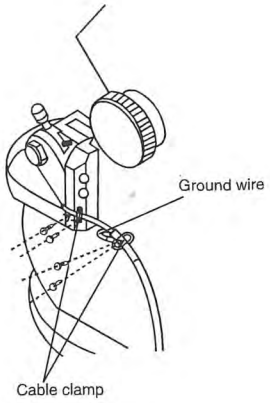


Figure 14-1

⑥Replace the prism unit with new one. At the same time, change the packing, too. Fasten the new prism unit to the main unit with the four screws.

⑦Restore the wire clamps together with the thermo-sensor wire to their original positions and fasten them with the four screws B and A in alphabetical order. At that time, pay heed to the wire so that it is arranged on the left side of the wire clamps.

⑧That is all for prism replacemet. Before starting measurement with the new prism, make sure to calibrate the scale (calibration).

Note: Do not loosen the two screws fixing the secondary prism and the hinge base.

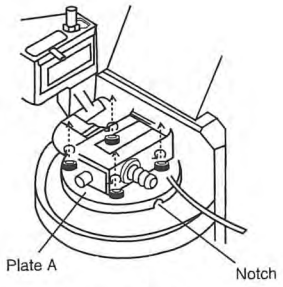


Figure 14-2

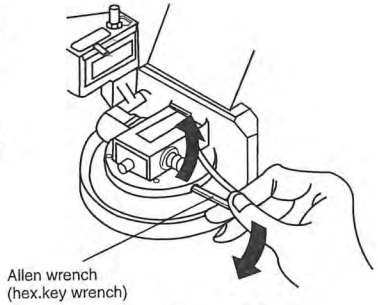


Figure 14-3

(2) LED Lamp

⚠ CAUTION

- When replacing the illuminating lamp, not only turn off the power switch but also disconnect the power cable from the AC outlet starting replacement work.
- Don't touch the plug with wet hand.
- When disconnecting the power cable from the outlet, make sure to do it by holding the plug.
  If the cable is pulled for disconnection, it may not only break the cable but also cause fire and electric shock.
- When replacing the illuminating lamp, wait for 5 minutes at least after turning off the power swicth with disconnection of the AC cable. If you touch the illuminating lamp just after it was switched off, there is a fear that you burns your hand on its hot surface.
- Replace the illuminating lamp with a specified lamp of the same rating. If any other lamp different in the rating is used, it may cause burns of external parts and breakdown of the instrument.

(2)-1 Lamp of sample illuminator

①Turn the head ring of the sample illuminator lamp holder counter-clockwise to remove it together with the lens, and carefully pull out the lamp holder (Figure 14-4).

Note: Don't pull out the lamp holder too much or with excessive force, otherwise the wires may break.

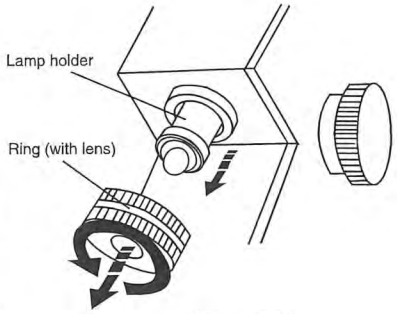


Figure 14-4

②Unscrew the lamp and remove it (Figure 14-5).

③Screw a new lamp into the socket of the lamp holder.

④Carefully press the lamp holder into the main unit.

⑤Fasten the lamp holder with the lens ring.

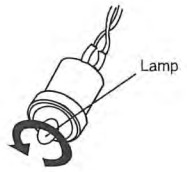


Figure 14-5

⑥ That is all for replacement of the lamp of the sample illuminator. After turning on the power switch, and check to see if the lamp goes on normally, or not.

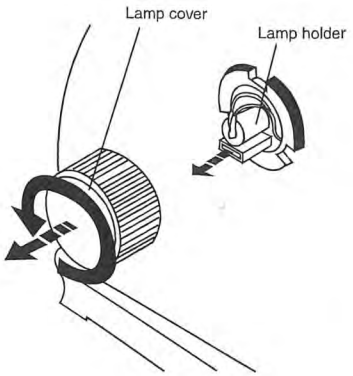


Figure 14-6

(2)-2 Lamp of scale field illuminator

① Turn the lamp cover of the scale field illuminator counterclockwise to remove it, and then detach the lamp holder from the guide plate by sliding it outwards carefully (Figure 14-6).

Note: Don't pull out the lamp holder too much or with excessive force, otherwise the wires may break.

② Unscrew the lamp and remove it from the lamp holder (Figure 14-7).

③ Screw a new lamp into the socket of the lamp holder.

④ Sliding the lamp holder on the guide plate, set it to the original position.

⑤ Fasten the lamp holder to the main unit with the lamp cover.

⑥ That is all for replacement of the lamp of the scale field illuminator.

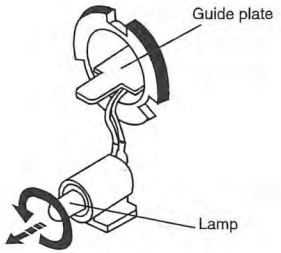


Figure 14-7

(3) Thermo-sensor unit

① Turn off the power switch of the digital thermometer.

② Disconnect the connector from the digital thermometer.

③ Open the secondary prism and remove the four screws A and B in alphabetical order (Figure14-8). Use a Phillips head (+) screwdriver to remove the screws A and B.

④ Remove the two screws C with the Allen wrench (hex. head key wrench) supplied with the unit, and then remove the prism open/shut handle (Figure 14-8).

⑤ Turn the metal base of the thermo-sensor unit counterclockwise with the 5mm wrench supplied with the unit and remove the thermo-sensor unit from the main prism (Figure14-9).

⑥ Apply liquid sealant supplied with the unit onto the threaded part of the thermo-sensor unit (Figure 14-10).

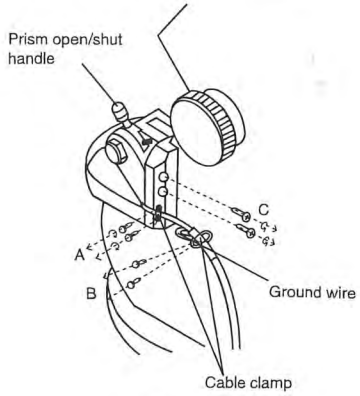


Figure 14-8

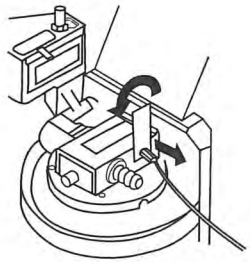


Figure 14-9



Figure 14-10

⑦ Insert the head of the thermo-sensor unit and the screw it into the tapped hole for the thermo-sensor unit by turning the metal base clockwise with the 5mm wrench supplied with the unit until it is tightly fastened (Figure 14-11).

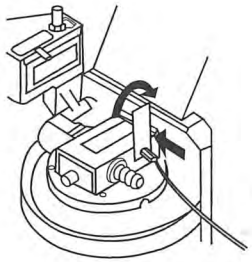


Figure 14-11

⑧ Fit the prism open/shut handle to the main unit and fasten it with the two screws C (Figure 14-12). After that, shut the secondary prism to check to see if it is firmly fixed or not.

⑨ Restore the wire clamps together with the thermo-sensor unit wire to their original positions and fasten them with the four screws B and A in alphabetical order (Figure 14-12). At that time, pay heed to the wire so that it is arranged on the left side of the wire clamps.

⑩ Insert the wire connector into the digital thermometer and turn on the power swich to check to see if the termo-sensor unit works normally while observing the indication of the digital thermometer. If there is something abnormal in the temperature indication, check all the connections and settings.

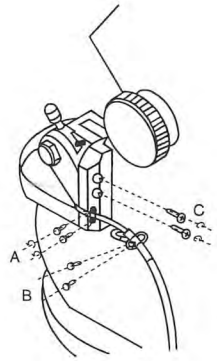


Figure 14-12

(4) Desiccant

The green color of the desiccant gradually fades as it gets close to saturation.
Check the desiccant regularly through the glass window on the left side of the main unit.
When it becomes pale green, replace the desiccant according to the following procedure.

① Unscrew the desiccant case and remove it from the main unit (Figure 14-13).

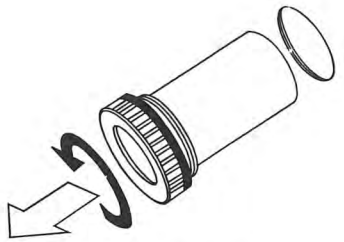


Figure 14-13

② Turn the cap of the desiccant case counterclockwise to remove it, and take all particles of the desiccant from the case (Figure 14-14).



Figure 14-14

Note: Carefully remove the cap not to lose the packing set inside.

③ Insert new desiccant particles in the desiccant case.
(Insert the separately packed green particles later so that they can be visible from the window.)

④ Cap the desiccant case tightly and set it in the main unit by screwing it.

15. Relation between Brix percent and refractive index (nD)

Relation between Brix percent and refractive index (nD) is shown in the following table for reference.

— Relation between Brix percent and refractive index (nD) —

%	n_D^{20}	%	n_D^{20}	%	n_D^{20}	%	n_D^{20}	%	n_D^{20}
0	1.33299	20	1.36384	40	1.39986	60	1.44193	80	1.49071
1	1.33442	21	1.36551	41	1.40181	61	1.44420	81	1.49333
2	1.33586	22	1.36720	42	1.40378	62	1.44650	82	1.49597
3	1.33732	23	1.36889	43	1.40576	63	1.44881	83	1.49862
4	1.33879	24	1.37060	44	1.40776	64	1.45113	84	1.50129
5	1.34026	25	1.37233	45	1.40978	65	1.45348	85	1.50398
6	1.34175	26	1.37406	46	1.41181	66	1.45584	86	1.5067
7	1.34325	27	1.37582	47	1.41385	67	1.45822	87	1.5094
8	1.34477	28	1.37758	48	1.41592	68	1.46061	88	1.5122
9	1.34629	29	1.37936	49	1.41799	69	1.46303	89	1.5149
10	1.34782	30	1.38115	50	1.42009	70	1.46546	90	1.5177
11	1.34937	31	1.38296	51	1.42220	71	1.46790	91	1.5205
12	1.35093	32	1.38478	52	1.42432	72	1.47037	92	1.5234
13	1.35250	33	1.38661	53	1.42647	73	1.47285	93	1.5262
14	1.35408	34	1.38846	54	1.42863	74	1.47535	94	1.5291
15	1.35568	35	1.39032	55	1.43080	75	1.47787	95	1.5320
16	1.35729	36	1.39220	56	1.43299	76	1.48040		
17	1.35891	37	1.39409	57	1.43520	77	1.48295		
18	1.36054	38	1.39600	58	1.43743	78	1.48552		
19	1.36218	39	1.39792	59	1.43967	79	1.48811		

Note:

Refractive index values for Brix 0 to 85% in the above table have been officially determined by ICUMSA (International Commission for Uniform Methods of Sugar Analysis held in 1974).

Further, refractive index for Brix 85 to 95% in the above table have been used in the scale of ATAGO Abbe Refractometers for many years, and the values approximately correspond to the refractive index values for Brix 85 to 95% in the reference table which ICUMSA announced in 1994.

16. Temperature correction table for sucrose solution

This table gives mass fraction corrections to refractometric tables for sucrose solutions at 589nm for temperatures different from 20°C.

Temperature (°C)	Measured Sucrose (mass fraction)																	
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
15	-0.29	-0.30	-0.32	-0.33	-0.34	-0.35	-0.36	-0.37	-0.37	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.37	-0.37
16	-0.24	-0.25	-0.26	-0.27	-0.28	-0.28	-0.29	-0.30	-0.30	-0.30	-0.31	-0.31	-0.31	-0.31	-0.31	-0.30	-0.30	-0.30
17	-0.18	-0.19	-0.20	-0.20	-0.21	-0.21	-0.22	-0.22	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.22
18	-0.12	-0.13	-0.13	-0.14	-0.14	-0.14	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15
19	-0.06	-0.06	-0.07	-0.07	-0.07	-0.07	-0.07	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.07
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	+0.06	+0.07	+0.07	+0.07	+0.07	+0.07	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.08	+0.07
22	+0.13	+0.14	+0.14	+0.14	+0.15	+0.15	+0.15	+0.15	+0.16	+0.16	+0.16	+0.16	+0.16	+0.16	+0.15	+0.15	+0.15	+0.15
23	+0.20	+0.21	+0.21	+0.22	+0.22	+0.23	+0.23	+0.23	+0.23	+0.24	+0.24	+0.24	+0.24	+0.23	+0.23	+0.23	+0.23	+0.22
24	+0.27	+0.28	+0.29	+0.29	+0.30	+0.30	+0.31	+0.31	+0.31	+0.32	+0.32	+0.32	+0.32	+0.31	+0.31	+0.31	+0.30	+0.30
25	+0.34	+0.35	+0.36	+0.37	+0.38	+0.38	+0.39	+0.39	+0.40	+0.40	+0.40	+0.40	+0.40	+0.39	+0.39	+0.38	+0.38	+0.37
26	+0.42	+0.43	+0.44	+0.45	+0.46	+0.46	+0.47	+0.47	+0.48	+0.48	+0.48	+0.48	+0.48	+0.47	+0.47	+0.46	+0.46	+0.45
27	+0.50	+0.51	+0.52	+0.53	+0.54	+0.55	+0.55	+0.56	+0.56	+0.56	+0.56	+0.56	+0.56	+0.55	+0.55	+0.54	+0.53	+0.52
28	+0.58	+0.59	+0.60	+0.61	+0.62	+0.63	+0.64	+0.64	+0.64	+0.65	+0.65	+0.64	+0.64	+0.63	+0.63	+0.62	+0.61	+0.60
29	+0.66	+0.67	+0.68	+0.70	+0.71	+0.71	+0.72	+0.73	+0.73	+0.73	+0.73	+0.73	+0.72	+0.72	+0.71	+0.70	+0.69	+0.67
30	+0.74	+0.76	+0.77	+0.78	+0.79	+0.80	+0.81	+0.81	+0.82	+0.82	+0.81	+0.81	+0.80	+0.80	+0.79	+0.78	+0.76	+0.75
31	+0.83	+0.84	+0.85	+0.87	+0.88	+0.89	+0.89	+0.90	+0.90	+0.90	+0.90	+0.89	+0.89	+0.88	+0.87	+0.86	+0.84	+0.82
32	+0.92	+0.93	+0.94	+0.96	+0.97	+0.98	+0.98	+0.99	+0.99	+0.99	+0.99	+0.98	+0.97	+0.96	+0.95	+0.93	+0.92	+0.90
33	+1.01	+1.02	+1.03	+1.05	+1.06	+1.07	+1.07	+1.08	+1.08	+1.08	+1.07	+1.07	+1.06	+1.04	+1.03	+1.01	+1.00	+0.98
34	+1.10	+1.11	+1.13	+1.14	+1.15	+1.16	+1.16	+1.17	+1.17	+1.16	+1.16	+1.15	+1.14	+1.13	+1.11	+1.09	+1.07	+1.05
35	+1.19	+1.21	+1.22	+1.23	+1.24	+1.25	+1.25	+1.26	+1.26	+1.25	+1.25	+1.24	+1.23	+1.21	+1.19	+1.17	+1.15	+1.13
36	+1.29	+1.30	+1.31	+1.33	+1.34	+1.34	+1.35	+1.35	+1.35	+1.34	+1.34	+1.33	+1.31	+1.29	+1.28	+1.25	+1.23	+1.20
37	+1.39	+1.40	+1.41	+1.42	+1.43	+1.44	+1.44	+1.44	+1.44	+1.43	+1.43	+1.41	+1.40	+1.38	+1.36	+1.33	+1.31	+1.28
38	+1.49	+1.50	+1.51	+1.52	+1.53	+1.53	+1.54	+1.54	+1.53	+1.53	+1.52	+1.52	+1.48	+1.46	+1.44	+1.42	+1.39	+1.36
39	+1.59	+1.60	+1.61	+1.62	+1.63	+1.63	+1.63	+1.63	+1.63	+1.62	+1.61	+1.59	+1.57	+1.55	+1.52	+1.50	+1.47	+1.43
40	+1.69	+1.70	+1.71	+1.72	+1.73	+1.73	+1.73	+1.73	+1.72	+1.71	+1.70	+1.68	+1.66	+1.63	+1.61	+1.58	+1.54	+1.51

17. Specifications

Model	NAR-3T
Measurement range	Refractive index(nD) : 1.30000 to 1.71000 Brix : 0.00 to 95.00%
Minimum scale	Refractive index(nD) : 0.0002 Brix : 0.1%
Measurement accuracy	Refractive index(nD) : ±0.0001 Brix : ±0.05%
Average dispersion value	nF-nC (to be caluculated according to conversion table)
Digital Thermometer	Indication range: 0.0 to 50.0°C (Accuracy:±0.2°C, Minimum indication: 0.1°C)
Measurement temperature range	5 to 50°C (Temperature range available of the circulating water)
Environmental conditions	・Use the instrument at an altitude below 2,000m (above sea level). ・Use the instrument indoors. ・Use the instrument where the temperature is between 5 to 40 °C. ・Use the instrument under the condition where humidity is 80% at 31°C or lower, falling linearly to 50% at 40°C. ・Main supply voltage fluctuation should not to exceed ±10% the nominal voltage. ・Installation categories (Overvoltage Categories):II ・The pollution degree is 2 (according to IEC60664).
Light source	LED Lamp (Approximating to wavelength of D-Line)
Power supply	AC100 to 240V, 50/60 Hz
Power consumption	5VA
Dimensions and Weight	Refractometer : 12(W)×31(D)×34(H)cm、9.0kg(main unit only) Digital thermometer : 10(W)×11(D)×7(H)cm、0.5kg

18. Repair and warranty

The Abbe Refractometer NAR-3T is a complicated precision instrument consisting of optical parts. It is very difficult to detect the cause of a trouble if there is something wrong in the refractometer. Therefore, repair and adjustment of the NAR-3T require special knowledge of not only optics but also the NAR-3T itself.
Do not disassemble or perfrom any repair on the unit other than the basic inspection and replacement of parts described in this operation manual (unless you have taken the maintenance course in our company and has been certified).
The warranty of this unit is one year after the date of purchase. Any trouble detected during the warranty period will be performed without charge. After the warranty has expired, the cost of repairs will be subject to evaluation. Ask your ATAGO distributor concerning this matter.
During the warranty period, if a person who has not taken the maintenance course at our company and has opened and tempered with the components within the casing, the warranty will be invalidated and a charge for repair will be assessed.
The prism is considered a consumable item. Therefore, any damage to the prism is not covered under the warranty and is subject to a repair costs.
All instruments received for repair are subject to a possible inspection fee. ATAGO does not warrant the problems which are caused by user's fault even though the unit is under warranty.

● Performance parts for repair

ATAGO will endeavor to secure the performance parts for repair up to seven years after manufacturing of this instrument is discontinued. Performance parts are those which are necessary to maintain the operation of this instrument. However, ATAGO may not be able to supply all parts due to discontinuation or modifications by our parts manufacturers. Please understand this matter. Performance part are available through your ATAGO distributor.

● Recommendation of periodic inspection and maintenance (Charged)

We recommend to have your NAR-3T inspected periodically (once in two years, or so) to ensure years of dependable and accurate use.
Ask your ATAGO distributor for the periodic inspection (charged).
Periodic inspection includes:
- Inspection, confirmation, and replacement of performance parts
- Inspection and adjustment of span
- Replacement of desiccant

ATAGO CO., LTD.

When asking about repair or other matters, be sure to notify us of the serial No. of your NAR-3T.