1311-E09

Digital Abbe Refractometer

DR-A1-Plus

Instruction Manual **Cat.No.1311**

ATAGO®

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1. Precautions for use

Introduction

Thank you for purchasing the "ATAGO's Digital Abbe Refractometer DR-A1-Plus". Before using your DR-A1-Plus, 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 DR-A1-Plus safely to prevent injury to you and other peaple 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 DR-A1-Plus 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 than the surface of the prism. Application on any other part of the instrument may result in a malfunction.

◇If this instrument is used measure very hot or highly acidic samples, 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 zero setting according to the instruction manual.
- The manufacturer 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

●Be sure to use the power cable included with the DR-A1-Plus.
If a power cable other than the one included is used, the rated voltage and polarity of the power may change, and may cause smoking or fire.

●Do not insert the power plug in 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.

Connecting a 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℃, and the flow rate of the circulating constant temperature bath should be 10 liter/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 instrument 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 manner.
  - 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.

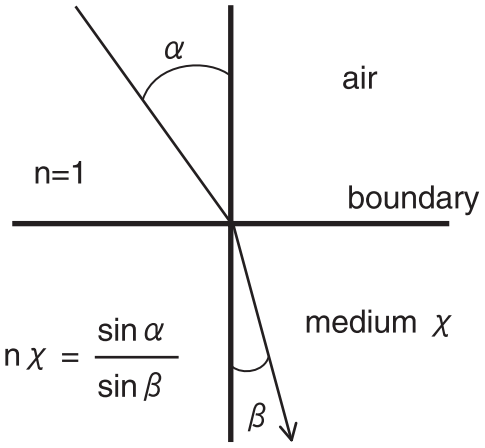
2. Refractive index and Brix scale (%)

(1) What is "refractometer" ?

When a chopstick is dipped in water in a glass, it looks bent. If the chopstick is dipped in thick sugar water, it looks bent much more. This phenomenon arises from "refraction of light beam". Applying this principle (with increase of solution in concentration, the refractive index becomes high in proportion to it) to practical use, Dr. Ernst Abbe (German) first devised the refractometer at the beginning of the 20th century.

(2) What is "refractive index" ?

When the refractive index of air at the atmostpheric pressure is "1" and a beam of light penetrates a certain medium χ, the ratio between the sine of refraction angle β and the sine of incident angle α to the surfactant is called the refractive index of the medium. Since refractive index varies depending on wavelength of light and temperature, it is expressed as follows.



n_D^t

n : expresses refractive index
t : temperature (℃)
D : D-line of sodium (589nm)

For example, the Refractive Index of water of 20℃
n_D^{20} = 1.33299 (nD=1.33299 in usual expression)

Note : Refractive index on the premise that the refractive index of vacuum is "1" is called absolute refractive index, but it is not used generally.

(3) Regarding Brix scale

Besides the standard refractive index scale, the DR-A1-Plus has the Brix scale (%) which is a measure of weight percentage of sugar (sucrose) contained in water solution. Since the Brix scale uses the refractive index of water (nD=1.33299) as the reference level (0%), indication of the Brix scale corresponds to the percentage of the sugar (sucrose) content in water solution. However, beverages and foods actually contain various kinds of disolving ingredients such as salt, protein, and so forth besides sugar, and total concentration of all water-soluble matters contained in solution is regarded as the soluble solid. When a sample of such a beverage, food or another solution is measured by the Brix scale, its indication nearly corresponds to percentage of the water-soluble solid contained in it. Therefore, the Brix scale is widely used as the most practical scale.

Note: Brix scale (%) is a standard sugar content scale recommended by ICUMSA, and its measurement value (percentage) is expressed by unit of "% mass (sucrose)" in the international unit (SI unit).

Note: For relation between Brix percentage and Refractive Index (nD), refer to page 37.

(4) Regarding "temperature compensation"

Even the same matter, its refractive index varies depending on temperature. When solution is measured by the refractometer, it reads different results from measurement to measurement owing to change in the temperature of the sample.

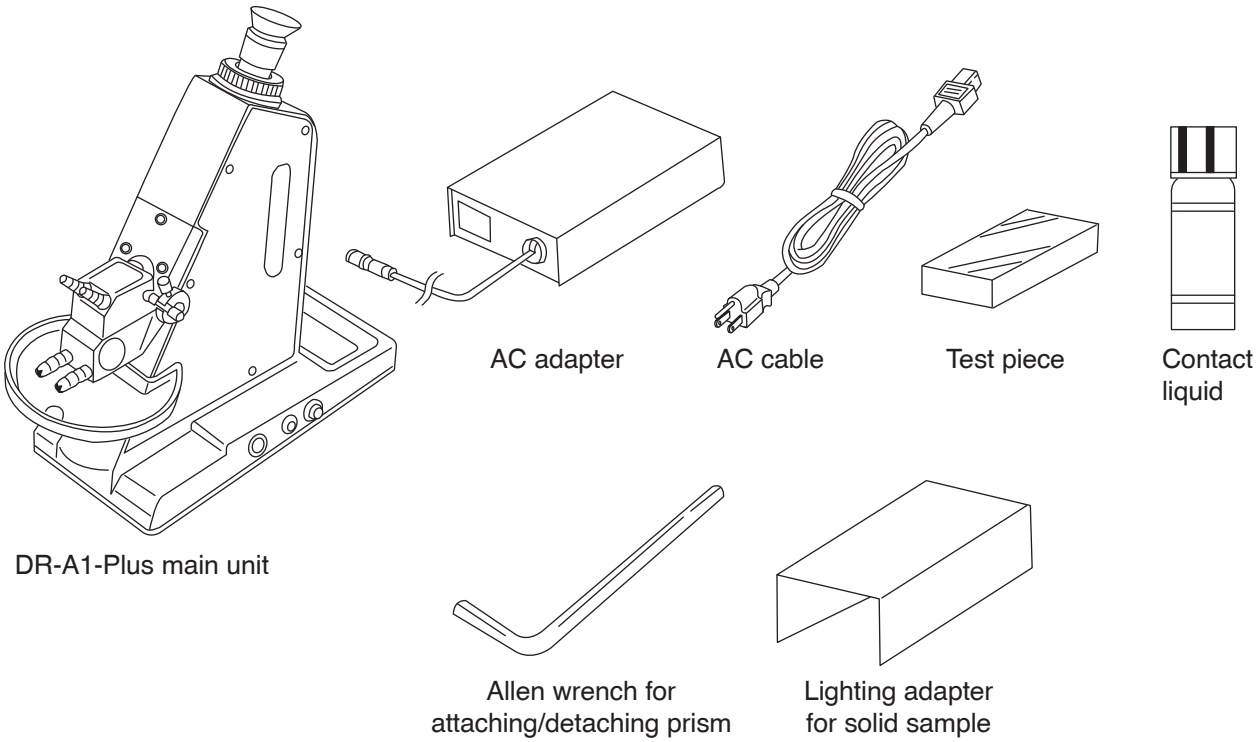
The DR-A1-Plus indicates a refractive index that is actually measured at the temperature shown in the temperature indicator in the refractive index (nD) measurement mode, while in the Brix% mode the DR-A1-Plus automatically compensates temperature change according to the temperature at the surface of the prism by the built-in microcomputer, therefore, indicated values are always the same as measured at 20℃ (when sample temperature is 5 to 50℃).

3. Unpacking and setup

(1) Unpacking

1) Take the contents out of the packing case and check to see whether there is any external damage observed or not.
2) Confirm that the following things have been containd in the case.

- ●DR-A1-Plus main unit ····· 1
- ●AC adapter (AD-13) ····· 1
- ●AC cable ····· 1
- ●Test piece (nD1.51) (for practicing measurement of solid matter) ····· 1
- ●Contact liquid (monobromonaphthalene, 4mL) (for practicing measurement of solid matter) ····· 1
- ●Allen wrench for attaching/detaching prism ····· 1
- ●Lighting adapter for solid sample ····· 1
- ●Instruction manual ····· 1
- ●Inspection certificate ····· 1



(2) Set up

1) Use a AC100 to 240V (50/60Hz) outlet for power supply to the DR-A1-Plus.
2) Set up the DR-A1-Plus in a convenient place where the ambient temperature is 5℃ to 40℃ and the DR-A1-Plus is free from such the environmental conditions as mentioned in 3) of the following.
3) Since the DR-A1-Plus employs very precise parts inside, avoid installing it in a dusty place, near heat source including heat generating apparatuses, a place where the sun directly shines on it, strong vibration or corrosive gas is generated, and so forth.
4) Place the DR-A1-Plus on a level surface of a stand/desk that is hardly affected by vibration. During setting up the DR-A1-Plus, carefully handle it not to apply it a strong shock.

4. Names and functions of main parts

(1) Main unit (Figs. 4-1, 4-2 and 4-3)

①Eyepiece:
For observing the boundary line between light and shade (refraction field) in the vision. On observing the eyepiece, turn it to bring focus into the crossline. The boundary line cannot be seen without sample on the prism.

②Sample illuminating lamp:
There are lamps to illuminate sample above and below the prism. Select the upper or lower lamp to illuminate the sample properly. For detail, refer to the description in page 28.

③Prism open-shut handle:
To open and shut the secondary prism. For opening, turn the handle front side and open the secondary prism by rasing the lever on the side part.

④Main prism:
Apply a sample onto the upper surface of the main prism for measurement. Carefully handle it so as not to damage it, because it is the important part to serve as the basis for refractive index measurement.

⑤Secondary prism:
Open the secondary prism to apply a sample onto the main prism. The secondary prism is used for lighting for liquid sample and its surface that contacts sample is frosted to create even light dispersion.

⑥Output terminal:
The signal cable to a printer or computer is connected here.

⑦Power input connector:
Connect the DC output cable of the AC adapter to this connector.

⑧Power switch:
Press this switch to turn on the refractometer and press it again to turn off the refractometer. After measurement finishes, turn off this switch without fail.

⑨Constant temperature water circulating nozzles:
For measuring sample at a constant temperature, these nozzles serve to circulate constant temperature water around the prism. Since the outer diameter of the nozzle is 9mm, it is recommended to connect tube whose inner diameter is 6 - 7mm if it is soft or 7 - 8mm if it is hard. For connecting tube, refer to page 15.

⑩Desiccant case:
There is a desiccant inside the case. When it moistens, the color of the desiccant changes from green to pale green. If so, turn the cap counterclockwise to take the desiccant out of the case and replace it with new one.

⑪Color compensator knob:
This knob is used to achromatize the boundary line appearing in the refraction field of vision for measurement.

⑫Measurement knob:
Turn this knob to match the boundary line appearing in the refraction field of vision with the intersection point of the crossline. As this knob is turned, the refractive index (nD) or the Brix value (%) appearing in the display continuously changes and the measurement value is displayed when the boundary line and the intersection point of the crossline match with each other.

⑬Rating label:
Ratings and serial number of the refractometer are shown on this label.

(2) AC adapter (Figs. 4-4, 4-5)

⑭Power output connector:
Connect the DC power output cable for the refractometer between this connector and the power input connector on the DR-A1-Plus.

⑮AC input connector:
Connect the AC power cable (supplied together with) between this connector and a mains AC outlet.

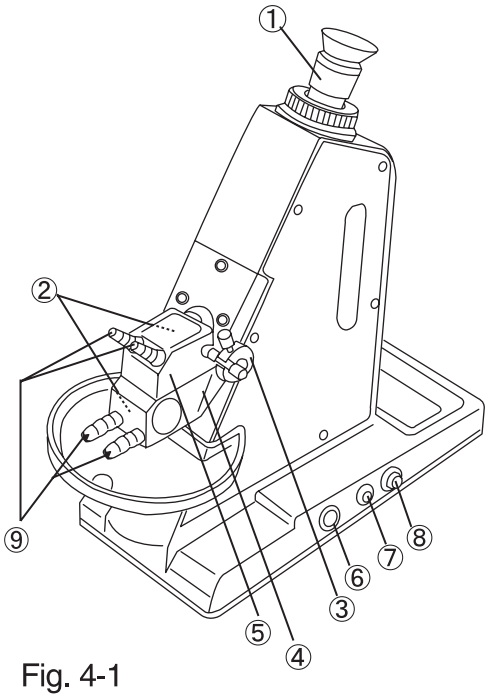


Fig. 4-1

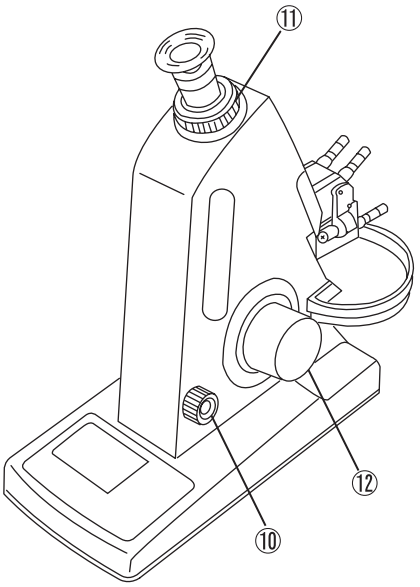


Fig. 4-2

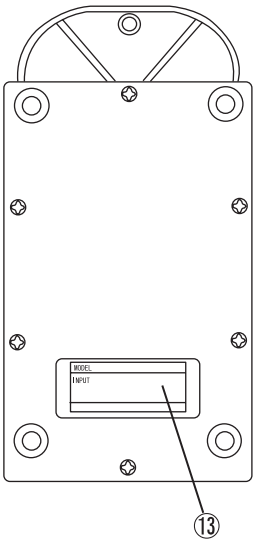


Fig. 4-3

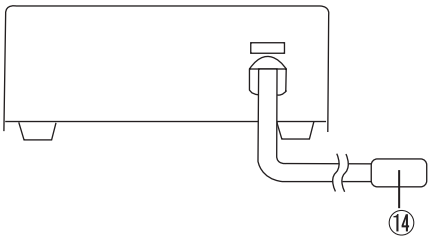


Fig. 4-4

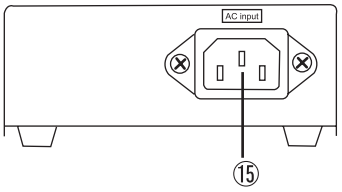


Fig. 4-5

(3) Display section (Fig. 4-6)

①Mode indicator:
Indicates one of three modes (nD, Brix, Test) currently in use.

②Measurement value indicator:
Indicates measurement value in refractive index (nD) or Brix value (%) digitally. In the Test mode, it does the number of the test mode, lamp position and quantity of light.

③Temperature indicator:
Temperature is constantly indicated during the measurement mode.

④Arrow keys:
Use these keys to change the mode in the test mode and to set various values.

- ● ∨ and ∧ keys ··· for decreasing and increasing the displayed number
- ● < and > keys ··· for moving cursor to another place

⑤SELECT key:
Use this key to switch the mode among "nD", "Brix" and "Test".

⑥SET key:
Use this key to fix the setting value and setting condition.

⑦PRINT key :
When the refractometer is connected to a DP-63 (C) Digital Printer, the measurement value is printed every time this key is pressed. When it is connected to a computer, the value is exported every time this key is pressed.

①: One of these modes is indicated in the normal condition.

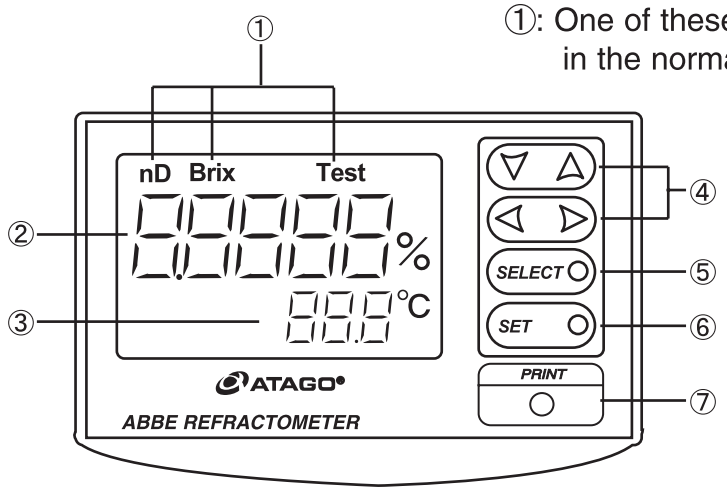


Fig. 4-6

5. Preparation before measurement

(1) Connection of cables and power supply to DR-A1-Plus

⚠ WARNING

- Don't plug the power cable into an outlet of specified mains supply of AC voltage other than AC100 to 240V (50/60 Hz).
- If the power cable (plug) is damaged, modified, or broken, don't use it. If such a cable (plug) is used, it may cause electric shock or fire.
- For repairing or replacing the cable (plug), ask the dealer or our distributor to do it.

⚠ CAUTION

- Don't touch the power cable (plug) with wet hand.
- When disconnecting the power cable from the outlet, make sure to do it by the plug. If the cable is pulled for disconnection, it may not only break the cable but also cause fire and electric shock.

①Insert the AC adaptor connector into the power port on the refractometer until you hear a click (Fig. 5-1①).

②Connect the AC cable to the AC adapter with the connector (Fig. 5-1②).

③Plug the other connector of the AC cable into a AC outlet (Fig. 5-1③).

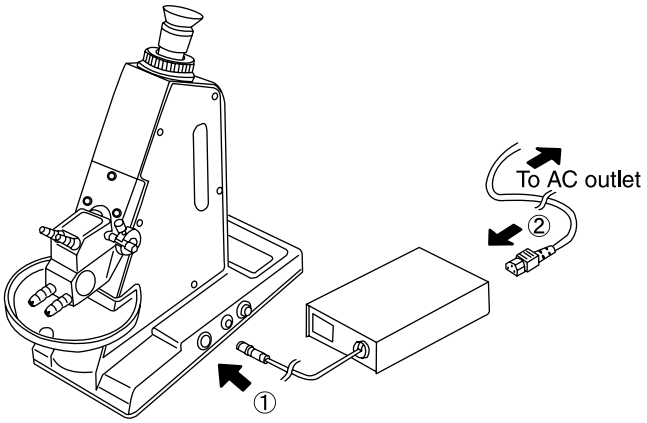


Fig. 5-1

Power Cable
Use only the following power cable. Using the wrong power cable could result in danger or fire.
The protection Class I equipment should be connected to PE (protective earth) terminal.

- For AC100-120V area
  UL Listed, detachable power cable set, 3 conductor grounding Type SVT, No. 18 AWG, 3m long maximum, rated at AC125V minimum.
- For AC220-240V area
  Approved according to EU/EN standards, 3 conductor grounding Type H05VV-F, 3m long maximum, rated at AC250V minimum.

④Press the power switch of the main unit and the power is supplied to it with indication of the present mode*, number (nD or Brix%) corresponding to the setting position of the measurement knob and temperature in the display (Fig. 5-2).

*The DR-A1-Plus is initially set to the refractive index measurement mode (nD) at shipment.

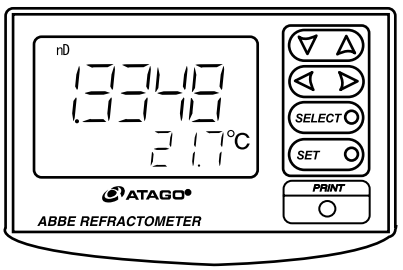


Fig. 5-2

(2) Connection a 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 (made of vinyl chloride) tube whose outer diameter is 12 - 13mm and inner diameter is 6 -7mm.
  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.

Since refractive index of liquid changes depending on temperature, it is recommended to use a circulating constant temperature bath together with the refractometer for obtaining stable measurement results at a constant temperature.
For connecting the circulating constant temperature bath with the DR-A1-Plus, use tubes to connect the four nozzles as shown in Fig. 5-3. Detailed connection will be explained below.

①Prepare the tube for connecting the circulating constant temperature bath to divide it into three pieces. The length of each piece should be:
Tube a and c = 90cm each, Tube b = 20cm

②Connect the tubes a and c to the water outlet nozzle and inlet nozzle of the circulating constant temperature bath respectively, and tightly fasten them with tube bands.

③Connect the other end of the tube a that is connected to the water outlet nozzle of the circulating constant temperature bath to the nozzle IN 1. Next, connect the nozzles OUT 1 and IN 2 with the tube b (20cm long). Lastly, connect the other end of the tube c that is connected to the water inlet nozzle of the circulating constant temperature bath to the nozzle OUT 2. Tightly fasten all the joint parts with tube bands without fail.

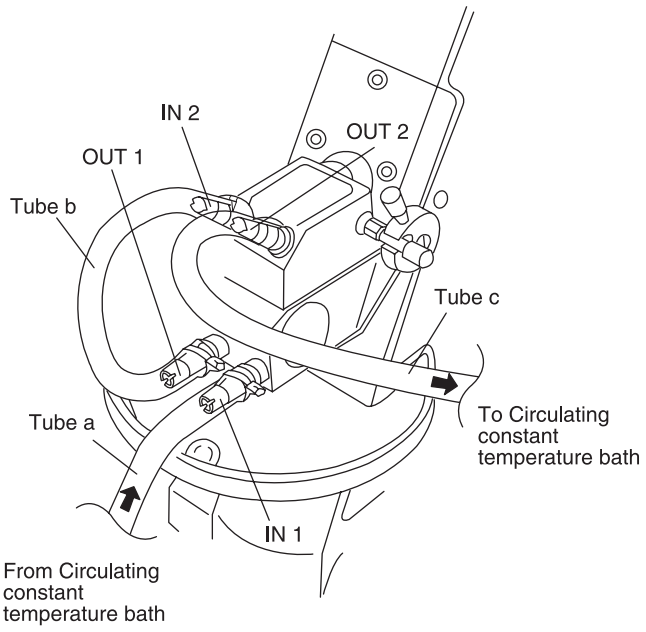


Fig. 5-3

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

Reference temperature of circulating constant temperature bath

It is natural that there is a difference in reading of temperature between the thermometer of the circulating constant temperature bath and that of the refractometer.
It results from ambient temperature affecting circulating water between the bath and the refractometer besides another reason that the refractometer is under influence of room temperature. Therefore, temperature of the sampling section is stable at a degree that is nearly the same as the room temperature rather than the internal temperature of the circulating constant temperature bath. Such being the case, it is required to adjust the temperature of the circulating constant temperature bath so that the temperature indicated in the display is maintained at the required degree.

④Use of tube band (See Fig. 5-4).

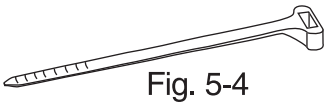


Fig. 5-4

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

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

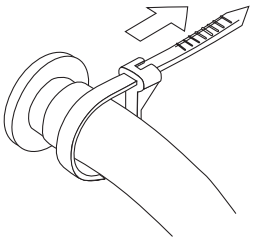


Fig. 5-5

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

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

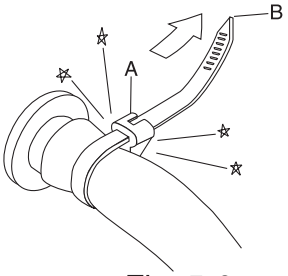


Fig. 5-6

④-4 After tightning the tube band, cut the tube band by the part C for cutting off the extra (See Fig. 5-7).

④-5 The tube band that were tightened once cannnot be reused.
For removing the tube band from the tube, cut it.

④-6 For fastening the tube with a tube band again, use a new tube band.

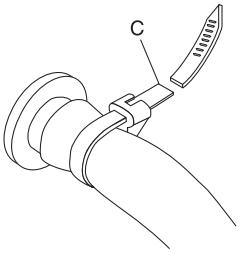


Fig. 5-7

④-7 Tube bands can be ordered through your ATAGO Distributor (refer to page 35).

6. Mode selection method

①Every time the SELECT key is pressed, mode indication changes from "nD", "Brix", "Test" to "nD" repeatedly in this order (Fig. 6-1).

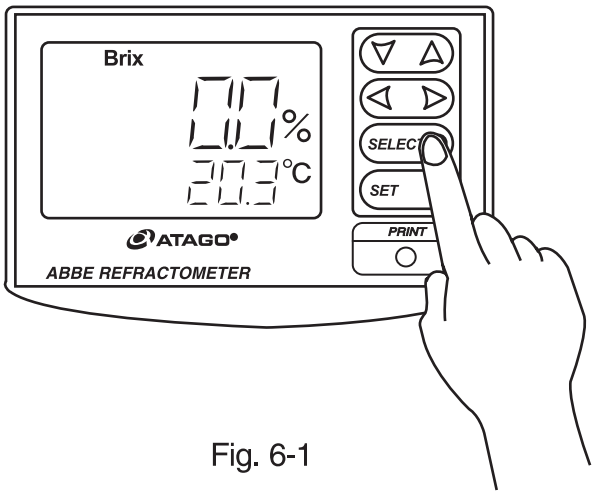


Fig. 6-1

②When the desired mode is selected, press the SET key (Fig. 6-2).

③Then, the measurement mode is set. To change the mode, repeat the procedure mentioned in ①.

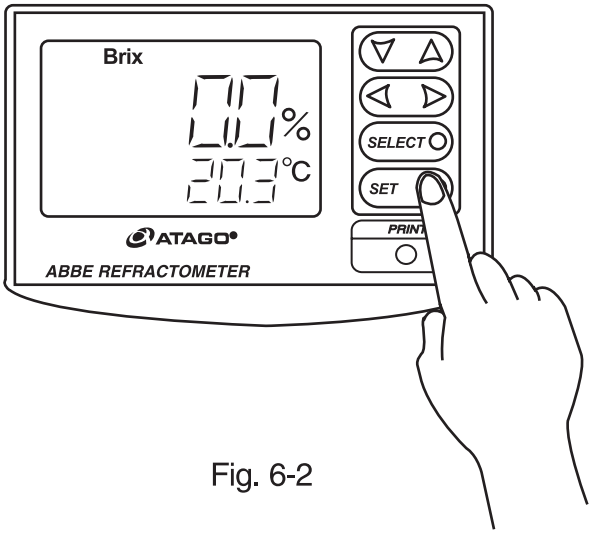


Fig. 6-2

* The mode is initially set to the refractive index measurement mode (nD) at shipment. The mode fixed last with the SET key will be held after power switch is turned off.

7. Reference point adjustment (Calibration)

⚠ 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 fail in measurement.

*Setting the reference point for the DR-A1-Plus

Setting of the reference point for the DR-A1-Plus should be made with purified water. In the mode on setting of the reference point, make the boundary line of the purified water meet at the intersection point of the cross hairs and press the SET key. The DR-A1-Plus is automatically calibrated by the refractive index of the distilled water at the measurement (indicated) temperature.

Note: Prepare purified water.

①Turn the prism open-shut handle to open the secondary prism. Carefully clean the main and secondary prism surface and then apply a few drops of purified water onto the main prism. Close the secondary prism (Fig. 7-1).

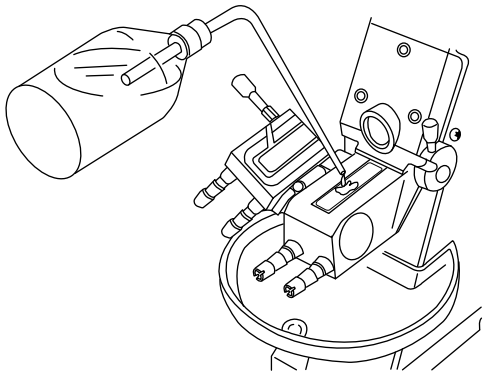


Fig. 7-1

②Observing through the eyepiece, turn the measurement knob to match the boundary line with the intersection point of the crossline (Fig. 7-2).
When the color blurs on the boundary line, turn the color compensator knob to remove the color blurring.

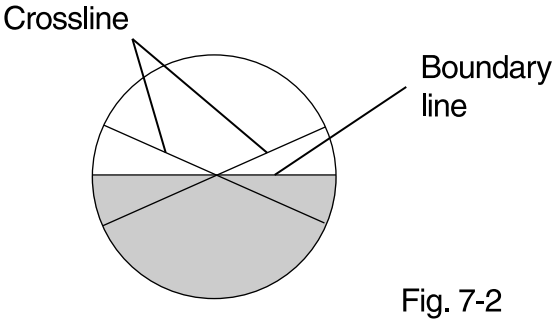


Fig. 7-2

③Press the SELECT key to show "Test" in the mode indicator. With indication of "Test", [1] appears in the measurement value indicator (Fig. 7-3). The test mode number [1] is for the reference point adjustment.

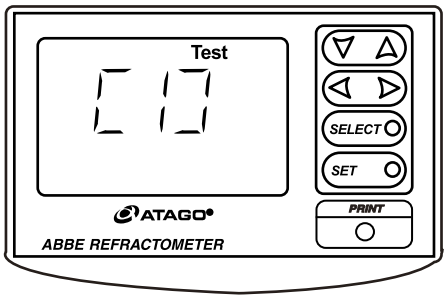


Fig. 7-3

④As [1] is appearing in the display, press the SET key and the refractive index at the present boundary line blinks in the display (Fig. 7-4).

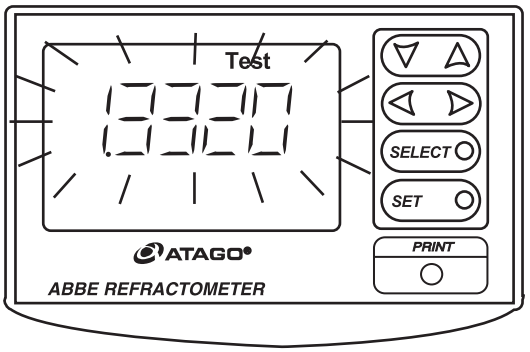


Fig. 7-4

⑤After confirming that the boundary line matches with the intersection point of the crossline, press the SET key again. The reference point is automatically adjusted inside the refractometer and [1] replaces the refractive index in the indicator. That is all for the reference point adjustment. For selecting a measurement mode (nD or Brix) again, press the SELECT key to select a desired mode and then press the SET key to set the refractometer to the selected mode.
Whenever a measurement or test is finished, make sure to clean the prism surface immediately after the operation.

Reference data Refractive index of distilled water

Measurement temperature°C	Refractive index	Measurement temperature°C	Refractive index	Measurement temperature°C	Refractive index	Measurement temperature°C	Refractive index
5	1.3339	17	1.3332	29	1.3321	41	1.3305
6	1.3339	18	1.3332	30	1.3319	42	1.3303
7	1.3338	19	1.3331	31	1.3318	43	1.3302
8	1.3338	20	1.3330	32	1.3317	44	1.3300
9	1.3337	21	1.3329	33	1.3316	45	1.3298
10	1.3337	22	1.3328	34	1.3314	46	1.3297
11	1.3336	23	1.3327	35	1.3313	47	1.3295
12	1.3336	24	1.3326	36	1.3312	48	1.3294
13	1.3335	25	1.3325	37	1.3310	49	1.3292
14	1.3334	26	1.3324	38	1.3309	50	1.3290
15	1.3334	27	1.3323	39	1.3308		
16	1.3333	28	1.3322	40	1.3306		

Note: The indicated values (after setting the reference point) may deviate from the above table by 0.0001 due to rounding off.

8. Measurement of liquid sample

⚠ WARNING

●When using this instrument for measuring solution containing substances harmful to humans, make sure to do it most carefully with gloves and a proper mask as well as with a good knowledge of the substances and the solution.

①Turn the prism open/shut handle to open the secondary prism, and apply sample to measure onto the main prism surface with a spoon, etc. (Fig. 8-1).

Note: Don't use any metalware such as a metal spoon for applying sample onto the prism because it may possibly damage the prism surface. Make sure to use plastics.

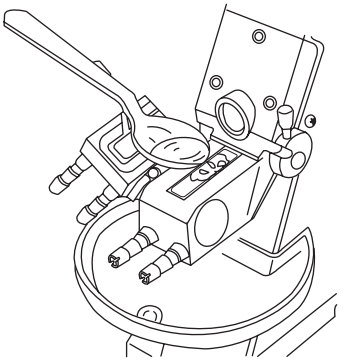


Fig. 8-1

②Close the secondary prism slowly. Turn the measurement knob while looking through the eyepiece so that the boundary line crosses with the intersection point of the cross lines (Figure 8-2).
Turn the color compensation knob to improve the clarity of the boundary line if necessary.

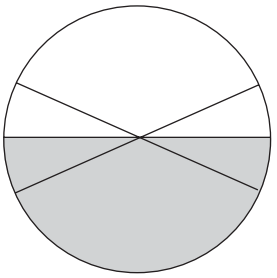


Fig. 8-2

* Filter out any solids that are not dissolved before measuring as they may damage the prism.

③The value indicated as the boundary line crosses the intersection point of the crossline is the measurement value of the sample (Fig. 8-3).

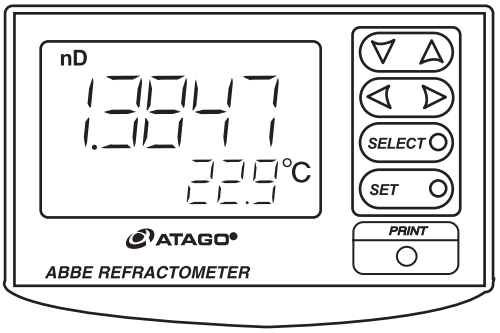


Fig. 8-3

Note: In the "nD" measurement mode the DR-A1-Plus indicates a value measured at the temperature shown in the lower right part of the display, while in the "Brix%" measurement mode it indicates a compensated value (%) that the actually measured value is internally converted for the temperature of 20°C.

9. Measurement of solid sample

⚠ WARNING

- When using this instrument for measuring matters harmful to humans, very carefully do it with gloves and a 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.
- Don't disassemble, repair, modify the refractometer by yourself because there is fear to get electric shock or burnt.
- If the refractometer is dropped or shocked strongly, immediately ask the dealer or our distributor to inspect it, If the refractometer is continuously operated in such a condition, it may cause smoking, burning or fire.

⚠ 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 fail in measurement.
- When measurement is complete, wipe up sample from the prism surface and its surroundings with soft tissues moistened with water first, and then wipe the wet parts with dry tissues to dry them up.
- After measurement of 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 tissues to dry up.

For measuring solid samples, use contact liquid, the film measurement 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 refrerring to the parts and consumable supplies list on page 35.

(1) Measurable samples

Solid samples that can be measured by the DR-A1-Plus are glass, plastics, film and others comforming to them, moreover, those samples must be transparent or semitransparent (In some cases it is hard to measure semitransparent solid samples owing to decrease of light transmission).

*Measurement of solid samples requires some experience to obtain satisfactory results, particularly in the case the quantity of contact liquid is improper to measurement or there is dust or air bubble between the solid sample and the main prism. For obtaining possibly accurate results from measurement of solid sample, it is recommended to practice measurement with the test piece supplied with the refractometer until the actually measured values fall within the allowable error for the DR-A1-Plus.

(2) Measurement of glass, plastics

(2)-1 Conditions of sample

- Optimum shape of sample is rectangular parallelopiped (approximately 20 - 30mm in length × 8mm in breadth × 3 - 10mm in thickness). It is desirable that respective sides meet each other at a right angle.
- Sample's surface to contact the prism should be polished (Optical polish finish is not required but the surface should be smoothed and polished. Poor planeness of the contact surface causes error in measurement. Lighting surface need not to polish).

(2)-2 Selection of contact liquid

Measurement of solid sample needs contact liquid to contact the sample to the prism. Monobromonaphthalene is supplied with the DR-A1-Plus as a contact liquid, however, it is the absolute conditon that the refractive index of contact liquid is higher than that of sample to measure. If the sample to measure seems to have a refractive index higher than that of the monobromonaphthalene ($n_D^{20} \approx 1.65$), use another contact liquid proper to the expected refractive index of the sample.

Examples of other contact liquids

Methyl sallcylilate... $n_D^{20} \approx 1.53$
Methylene iodide... $n_D^{20} \approx 1.73$
Solution of sulfur in Methylene iodide... $n_D^{20} \approx 1.74$ to 1.78 (depending on sulfur density)

Note: Since some contact liquids are very corrosive, select a contact liquid not to get sample corroded.

(2)-3 Measurement

①Turn the prism open-shut handle to open the secondary prism (Fig. 9-1).

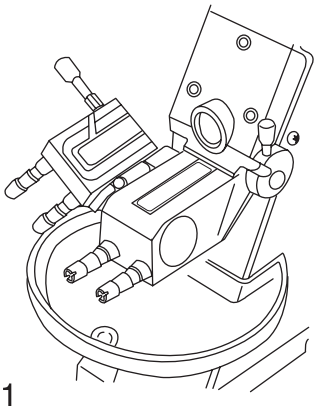


Fig. 9-1

②Put a tiny quantity of contact liquid on the center of the prism.
In the case of a test piece of an accessory (for practicing measurement of solid matter) and a glossy and flat glass sample, put a tiny quantity of contact liquid on the center of the glass surface to contact the prism (Fig. 9-2). One drop of 1mm in diameter is a proper quantity.

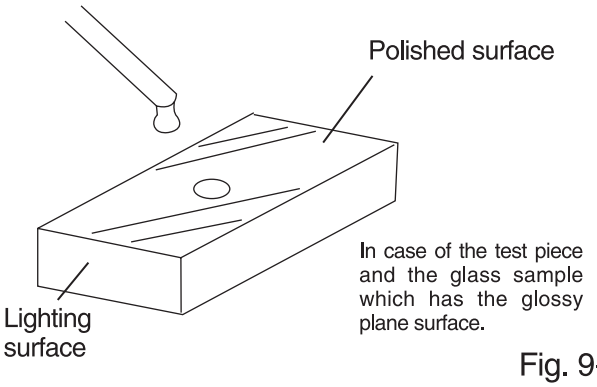


Fig. 9-2

③Put the sample on the center of the prism with careful position of daylighting and contacting face (Fig. 9-3). Thinly splay the contact liquid on the entire spacing of the sample and the prism. When the contact liquid dose not spread, by putting a thin stick tipped with the contact liquid on a spacing of the sample and the main prism, splay it. In addition, error will cause in measurement if the sample does not adequately contact with the prism because of too much contact liquid. In such case, run off extra contact liquid by slightly pressing down the top of the sample. Remove the surplus liquid which runs off the prism by pressing such as the edge of tissue paper.

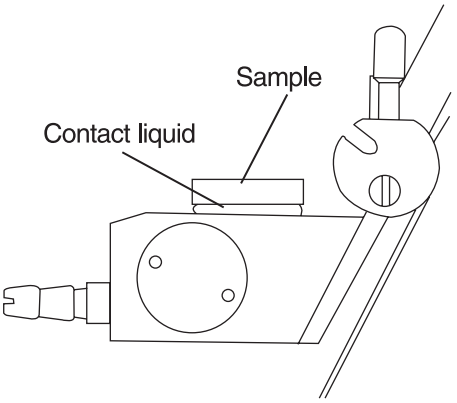


Fig. 9-3

④Put the lighting adapter for solid sample supplied with the DR-A1-Plus on the main prism so as to position the inner reflector in the side of the nozzle for the circulating water (Fig. 9-4).

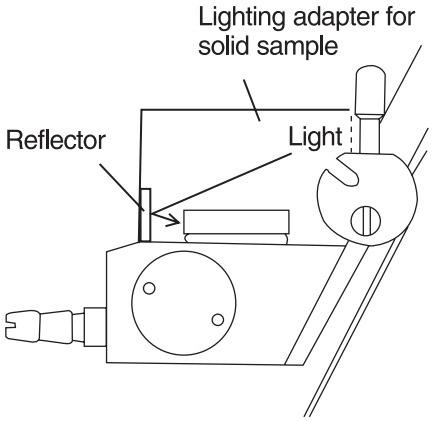


Fig. 9-4

⑤While looking through the eyepiece, turn the measurement knob so that the boundary line crosses the intersection point of the crossline while looking through the eyepiece (Fig. 9-5). If there is color blurring in and near the boundary line, turn the color compensator knob to remove it.

⑥The value indicated as the boundary line meets the intersection point of the crossline is the measurement value of the sample.

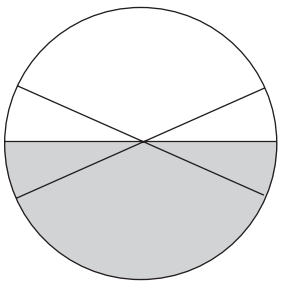


Fig. 9-5

(3) Measurement of film

Note: Measurement of film needs the "Measuring set for film" that is supplied optionally.

(3)-1 Conditions of sample

●Cut off the sample to be in size of 20 to 30mm long by 8mm bread approximately.
●Every cut side must be smooth and clean.

(3)-2 Selection of contact liquid

Measurement of solid sample needs contact liquid to contact the sample to the prism. Monobromonaphthalene is supplied with the DR-A1-Plus as a contact liquid, however, it is the absolute condition that the refractive index of contact liquid is higher than that of sample to measure. If the sample to measure seems to have a refractive index higher than that of the monobromonaphthalene ($n_D^{20} \approx 1.65$), use another contact liquid proper to the expected refractive index of the sample (refer to the description in page 22 (2)-2).

(3)-3 Measurement

①Turn the prism open-shut handle to open the secondary prism (Fig. 9-6).

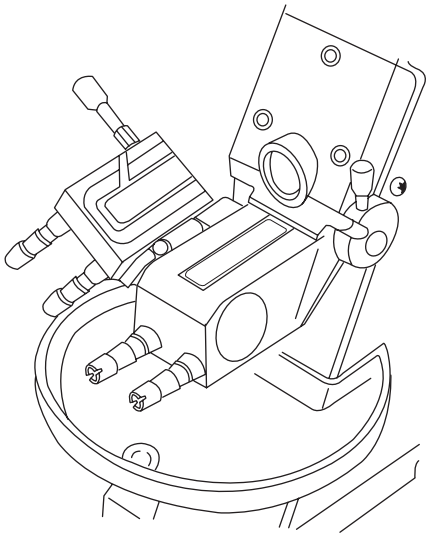


Fig. 9-6

②Fit the light dispersion plate of the "Measuring set for film" to the light emitting window of the DR-A1-Plus (Fig. 9-7).

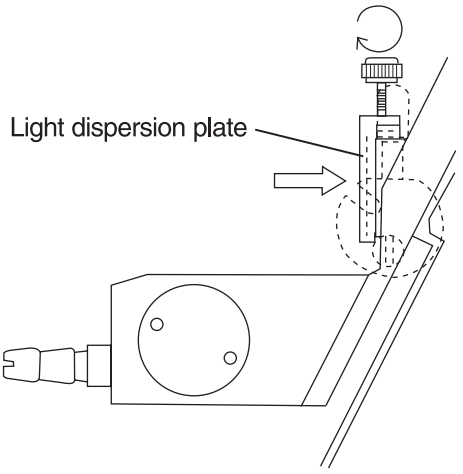


Fig. 9-7

③Apply a small quantity* of contact liquid onto the contact surface of the sample (Fig. 9-8).

* One drop of 1mm in diameter is proper quantity.

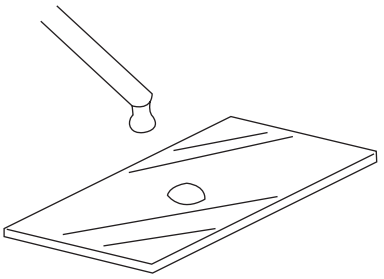


Fig. 9-8

④Put the sample with the contact liquid applied side down on the main prism and tightly contact them to each other (Fig. 9-9).

Note: Too much contact liquid not only causes error in measurement but also disturbs measurement.

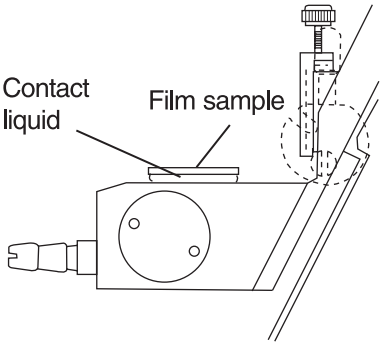


Fig. 9-9

⑤Apply contact liquid onto the upper surface of the sample put on the main prism, and put the lighting prism of the "Measuring set for film" with the polished side down on the sample (Fig. 9-10).

⑥While looking through the eyepiece, turn the measurement knob so that the boundary line crosses the intersection point of the crossline while looking through the eyepiece (Fig. 9-11). If there is color blurring in and near the boundary line, turn the color compensator knob to remove it.

⑦The value indicated as the boundary line meets the intersection point of the crossline is the measurement value of the sample.

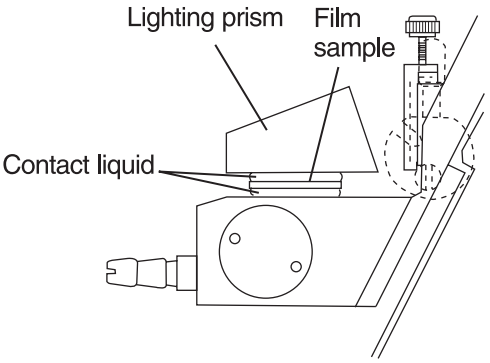


Fig. 9-10

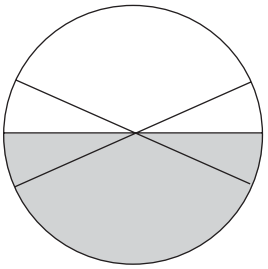


Fig. 9-11

(4) Measurement of double refraction

Note: Measurement of double refraction needs the "Polarizing eyepiece" that is supplied optionally. Measurement of film sample for dauble refraction needs the "Measuring set for film" as same as the preceding procedure.

Polymer film and so third have different refractive indices in respective directions of machining direction of the film (Y axis), right angle to machining direction (X axis) and thickness direction (Z axis) as illustrated by Fig. 9-12. This phenomenon is called "double refraction", and refractive index must be measured for each axis.

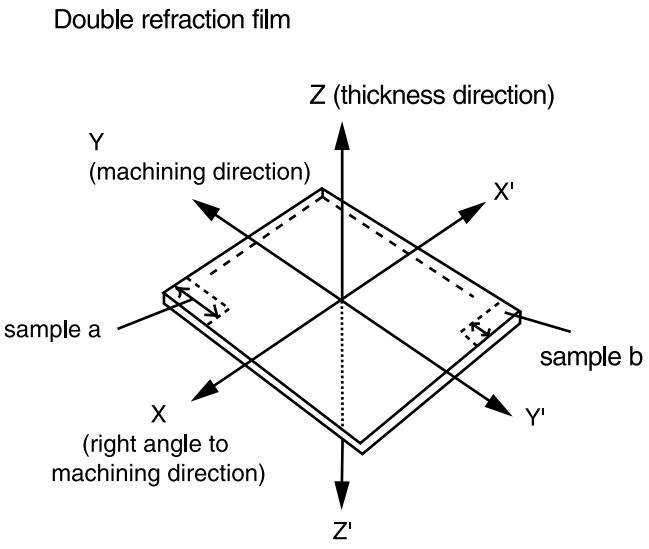


Fig. 9-12

(4)-1 Conditions of sample

Referring to Fig. 9-12, make two sample pieces a and b (different in X and Y axes from each other as shown in the figure) by cutting out the material to be measured for double refraction (carefully handle the sample pieces a and b not to mistake them for each other). Conditions (shape and size, etc.) of samples should conform to the measurement conditions of glass-plastics and film samples.

(4)-2 Selection of contact liquid

Follow the measurement procedure for glass-plastics and film samples.

(4)-3 Attaching polarizing eyepiece to DR-A1-Plus

① Remove the rubber hood (Figure 9-13).

② Loosen all 4 screws, then pull up and remove the part Figure 9-14.

③ Fit the eyeypiece (Figure 9-15) comes with the polarizing eyepiece on the refractometer (Figure 9-16), and tighten 4 screws.

④ Fit the polarizing eyepiece on the body tube (Figure 9-17).

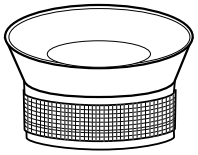


Figure 9-13

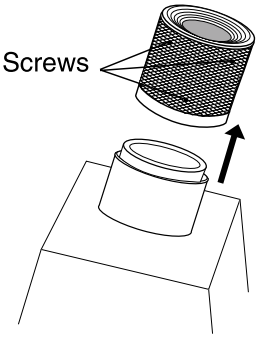


Figure 9-14

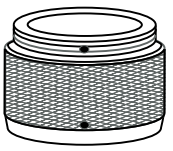


Figure 9-15

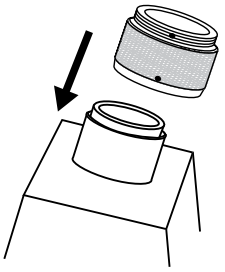


Figure 9-16

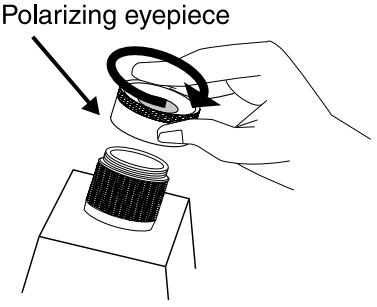


Figure 9-17

(4)-4 Measurement

①Set the sample piece a on the main prism. For detail of setting and lighting, refer to the procedure for glass, plastic and film samples. Since the polarizing eyepiece can be revolved, turn it to change the polarization direction. The polarization direction is indicated by the point marking as shown in Fig. 9-18.

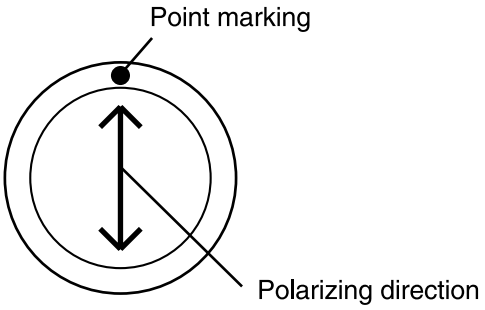


Fig. 9-18

●To measure refractive index in the Z axis, set the point mark at the topmost position (Fig. 9-19). To measure refractive index in the X axis, set the point mark sideways (Fig. 9-19).

②Then, set the sample piece b on the main prism. When the polarizing eyepiece is set at the topmost position, the sample piece b can be measured for the refractive index in the Z axis. On the other hand, when the polarizing eyepiece is set sideways, the sample can be measured for the refractive index in the Y axis.

●Refractive index of the Z axis will be obtained from both the two samples (a and b). Either of the results can be adopted. If there is a difference between the two measured values, adopt an average value of the two.

Setting orientation of sample and polarizing eyepiece

Measuring direction	Thickness direction (Z axis)	Right angle to machining direction (X axis)	Thickness direction (Z axis)	Machining direction (Y axis)
Measuring sample	a	a	b	b
Setting orientation of double refractive sample (↕expresses the Machining direction [Y axis].)	Light ↓↓ ↕	Light ↓↓ ↕	Light ↓↓ ↔	Light ↓↓ ↔
Setting orientation of polarizing eyepiece (↕expresses Polarizing direction.)	↕	↔	↕	↔

Fig. 9-19

10. Test mode

The DR-A1-Plus provides three kinds of test modes. This chapter gives explanation of the two test modes; [2] (LED adjustment) and [3] (LCD test).

Details of test modes by numbers

Test mode No.	Description	Page
[1]	Reference point adjustment (Calibration)	P.18
[2]	LED adjustment	P.28
[3]	LCD test	P.30
[4]	Sample numbering for printer and computer	P.33
[5]	Sample average for printer and computer	P.34

(1) Mode [2] (LED adjustment)

* The mode [2] is provided for selecting one lamp from the two lighting lamps located above and below the prism assembly respectively as well as for adjusting the quantity of light.

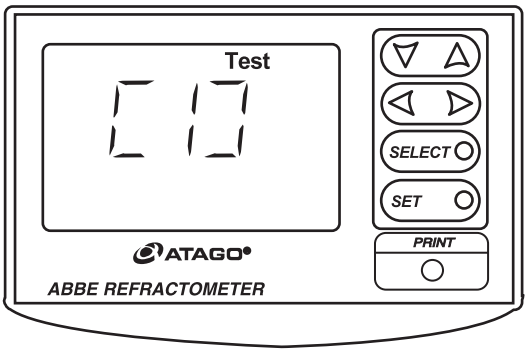


Fig. 10-1

①Press the SELECT key until the mode indicator shows "Test". As "Test" appears in the display, [1] appears in the measurement value indicator (Fig. 10-1).

②Change the indication [1] to [2] by pressing the ∨ or ∧ key. As the indication [1] changes to [2], press the SET key to select it (Fig. 10-2).

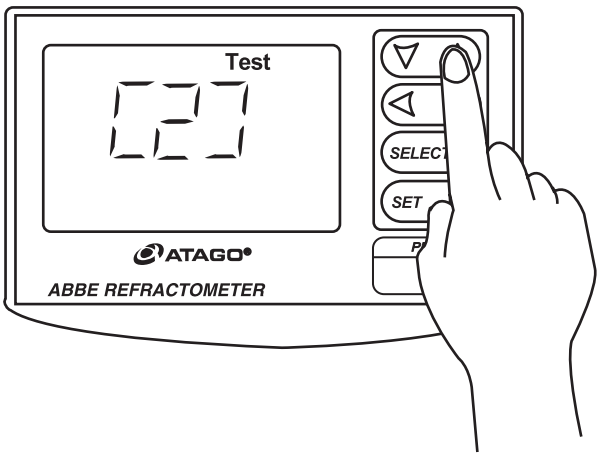


Fig. 10-2

③Then, the indicator shows the lamp being selected with an indication of −1− or −2−. Indication −1− expresses the upper lamp while −2− does the lower lamp. Use the ∨ or ∧ keys to select a desired lamp, and press the SET key for decision (Fig. 10-3).

* Initial lamp setting at shipment is −1− (upper lamp).

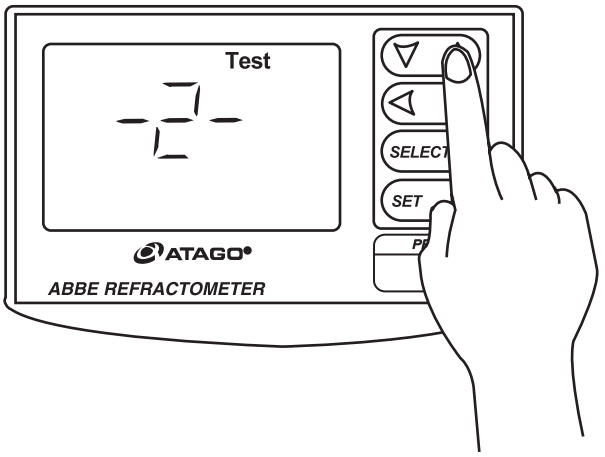


Fig. 10-3

* The upper lamp is suitable for measuring clear sample.

* If the field of vision is dark and the boundary line is invisible because the sample is unclear or colored, use the lower lamp for measuring it. Lighting with the lower lamp replaces light and dark sections in the field of vision with each other and decreases the contrast between them, however, the boundary line is in the same position as the upper lamp is used.

④After the SET key is pressed, quantity of light is displayed. Press the ∨ or ∧ key to adjust the quantity of light (100 steps from 0 to 100) and press the SET key for decision (Fig. 10-4).

* Quantity of light is initially set to 80 at shipment.

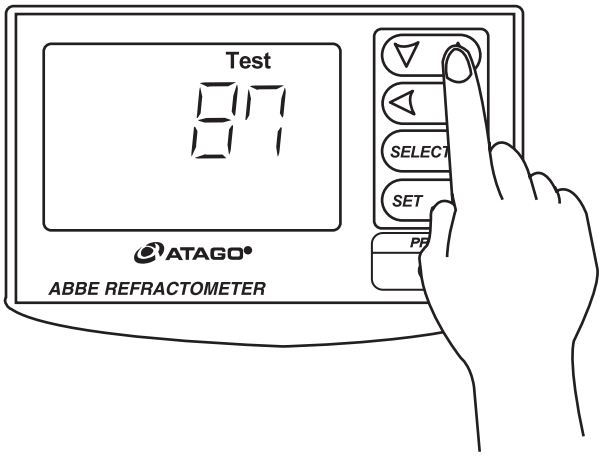


Fig. 10-4

⑤The indication returns to [2]. That is all for the LED adjustment. Select a desired measurement mode (nD or Brix) with the SELECT key and then press the SET key to set the refractometer to the mode.

(2) Mode [3] (LCD test)

* This mode is provide for checking to see whether there is faulty LCD segment (results in chipped character) in the LCD or not.

①Press the SELECT key to select the "Test" mode. With the "Test" appearing in the indicator, [1] is displayed in the measurement value indicator (Fig. 10-5).

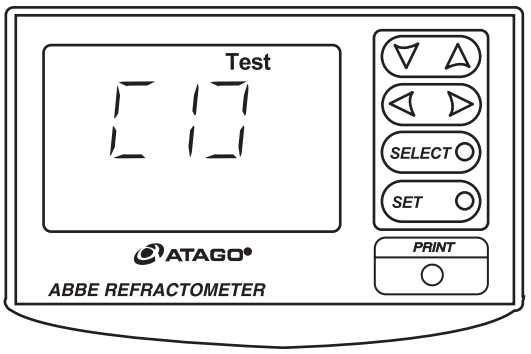


Fig. 10-5

②Change the indication [1] to [3] with the ∨ or ∧ key, and press the SET key for decision (Fig. 10-6).

③As each segment of the LCD goes on and out one after another sequentially, check to see if there is a defective segment or not (Fig. 10-7). After confirming that all the segments are normal, press the SELECT key and the indication returns to [3].

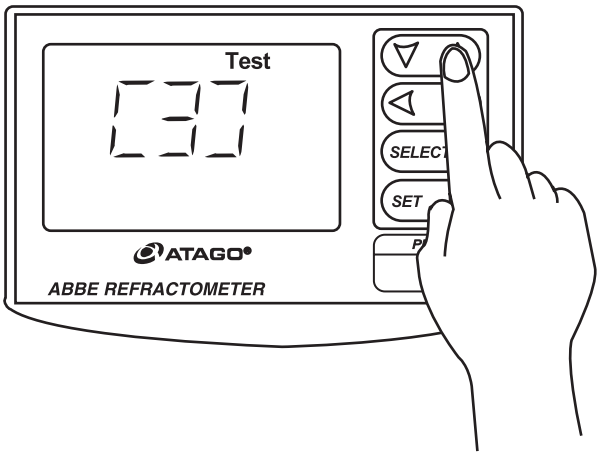


Fig. 10-6

④With [3] appearing in the display, again press the SELECT key to select a desired measurement mode (nD or Brix), Finally, press the SET key to set the refractometer to the selected mode.

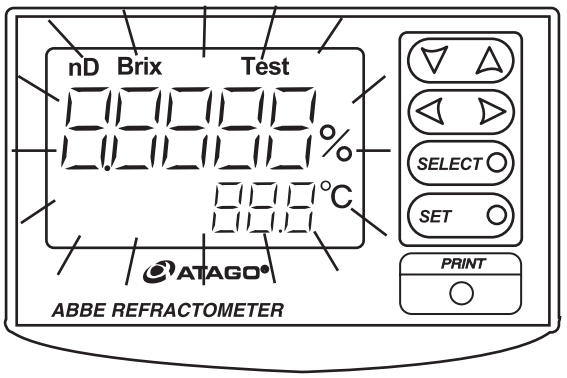


Fig. 10-7

11. Exporting Data to Printer or Computer

◆The DR-A1-Plus Refractometer can be connected to either the DP-63 (C) Digital Printer or a computer at any given time for data recording purposes.
◆The printer and computer share the same port for connection to the refractometer. Only one device at a time can be used.
◆Press the PRINT key on the refractometer to print the measurement value to the printer.
◆Press the PRINT key on the refractometer to export the measurement value to the computer.
◆The content exported is exactly the same for the printer and computer.

(1)Connection of refractometer and digital printer with each other

⚠ WARNING

◇When connecting an optional digital printer to the refractometer, make sure to turn off the power switch of the respective instruments and unplug the AC power cable of the refractometer and the AC adapter for the printer from the outlet beforehand.
If connection is performed as the instruments are turned on, it may cause an electric shock.

⚠ CAUTION

◇Be sure to turn off the printer first after use. On rare occasions, turning off the refractometer first may result in printer malfunction.

① Connect the printer (sold separately) to the instrument.
* Refer to the printer's instruction manual.

② Be sure that the printer and the refractometer are connected to each other.
First, turn on the printer. Then, turn on the refractometer.
An opening message will be printed out.
※After the printer and the refractometer were connected correctly and were turned on, the operation of the printer is not needed. Press the PRINT key on the refractometer every time a measurement is taken.

③ Be sure to turn off the printer first after use.

[Accessories and Consumables]

Name	Cat.No./Part No.	Remarks
Digital Printer DP-63(C)	Cat.No.3136	Thermal line dot print (Included: signal cable)
Printer paper	RE-8412	4 rolls in a set Width : 112mm Length : 28m
Printer paper for long-term storage	RE-8414	

(2)Connection of refractometer and PC

⚠ WARNING

◇When connecting an optional digital printer to the PC, make sure to turn off the power switch of the respective instruments and unplug the AC power cable of the refractometer from the outlet beforehand.
If connection is performed as the instruments are turned on, it may cause an electric shock.

①Disconnect the AC power cable of refractometer from the mains outlet.

②Make sure that Windows has started correctly and completely.

③Connect the refractometer and computer with the data cable for computer. Attach the special connector to the printer/RS-232C port of the refractometer (Fig. 11-1) and the D-Sub 9-pin connector to the serial communication port of the computer.

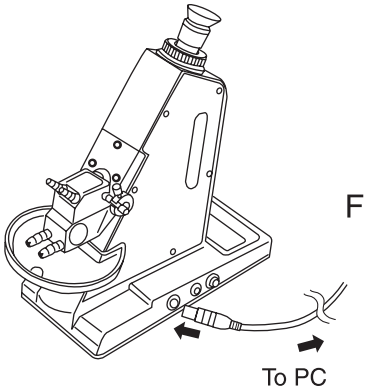


Fig.11-1

④Start the terminal emulation (communication) program.

⑤Turn on power to the refractometer. The "DR-A1" or "ATAGO" logo is sent to the computer.

⑥After taking a measurement, press the PRINT key to export the value.

※ The content exported is exactly the same for the printer and computer. Settings, such as numbering samples and setting the number of measurements to be taken for average, can be configured in the same way as the printer.

BAUDRATE	2400
DATA LENGTH	7bit
PARITY	EVEN
STOP	1bit
Flow control	none

※The COM port number may vary by computer. Check the port number once the connection is established.
※Use a terminal emulation (communication) program, such as HyperTerminal or Tera Term.

[Accessorie]

Name	Part No.	Remarks
Cable for RS-232C	RE-15305	Special connector to refractometer D-SUB 9-pin connector to computer

(3) Sample numbering for printer and computer

Set the number that sample numbering is to start at.

①Press the SELECT key to select the "Test" mode.

②Display the [4] on the screen, using the ∨ ∧ keys (Fig. 11-2). Press the SET key. The screen in Figure 11-3 will appear.

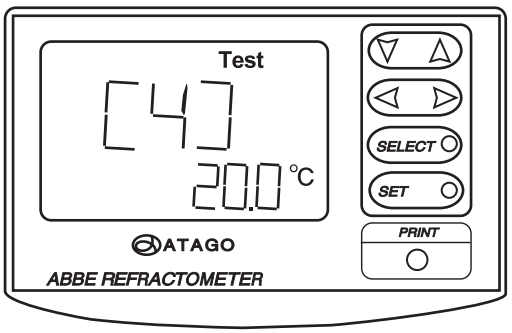


Fig.11-2

For example, if it is desired to start printing from the sample number 251, enter "1" in the first place (blinking place) with the < > key, and press the < > key to move the cursor position to the second place and enter "5" with the ∨ ∧ key, and move the cursor position once more to the third position and enter "2" in the same manner.

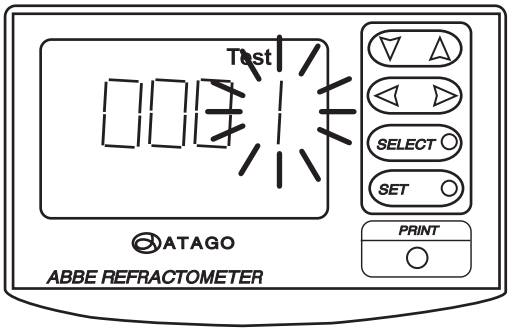


Fig.11-3

③Press the SET key. The indication on the display changes as shown in Fig. 11-4.

That all for setting the sample number to start printing.

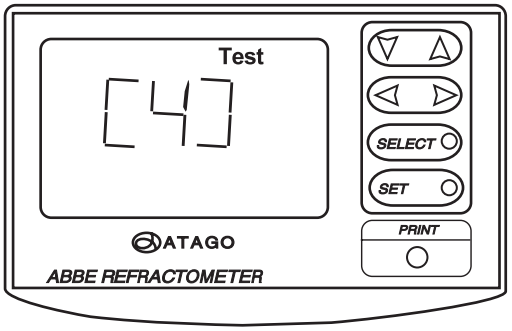


Fig.11-4

(4) Sample average for printer and computer

Set whether or not to export average measurement value as well as the number of measurements taken to calculate an average.

①Press the SELECT key to select the "Test" mode.

②Display the [5] on the screen, using the ∨ ∧ keys (Fig. 11-5). Press the SET key. The screen in Fig. 11-6 will appear.

When the indication on the display is [01], no average value is printed/exported because it means only one measurement and it is impossible to calculate average.
For example, if it is desired to printed/exported an average value of 12 measurement results, enter "2" in the first place (blinking place) with the < > key and move the cursor position to the second place with the ∨ ∧ key to enter "1".
The maximum number of times to calculate average value is 20.

③Press the SET key. The indication on the display changes as shown in Fig. 11-7.

That all for setting of the number of times to find average value.

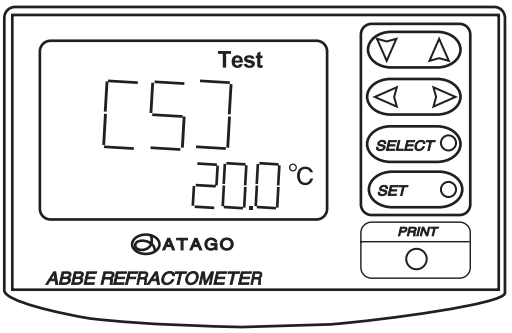


Fig. 11-5

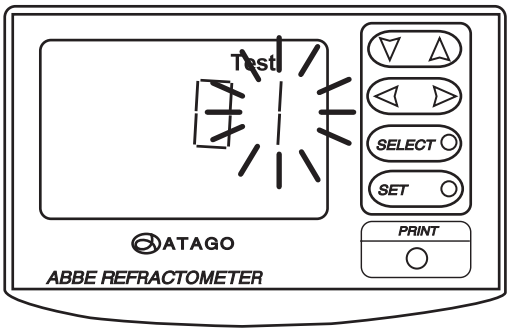


FIg. 11-6

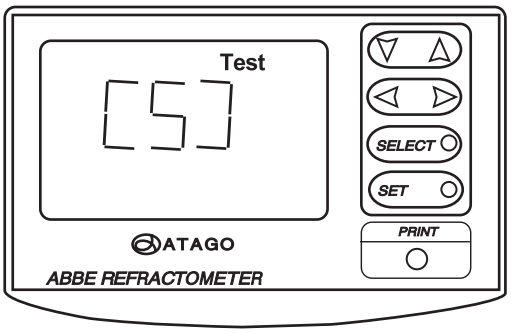


Fig. 11-7

(5)Examples of exported data

Below are examples of measurement data exported to a printer or computer.

①Refractive index measurements

```
    *  DR-A1  *
ATAGO Co.,LTD TOKYO JAPAN

No.        nD        TEMP
0001    1.3330       20.0
0002    1.3329       20.0
0003    1.3329       20.0
```

②Brix measurements and an average of 3 measurements

```
    *  DR-A1  *
ATAGO Co.,LTD TOKYO JAPAN

No.        Brix      TEMP
0004       12.0      25.0
0005       12.2      25.1
0006       12.1      25.2
-------------------------
AVERAGE    12.1      25.1
```

※Either the "DR-A1" or "ATAGO" logo is printed/exported only when the refractometer is turned on.
※In the nD measurement mode, the sample number (No.), refractive index value (nD), and temperature (TEMP) are displayed. In the Brix measurement mode, the sample number (No.), Brix value, and temperature (TEMP) are displayed.
※The print items (No., nD/Brix, and TEMP) are printed/exported only for the first measurement taken after the unit is turned on, or after the measurement mode is switched between nD and Brix.

12. Replacement of consumable supplies

1. Consumable supplies to be replaced by user

The following elements of the refractometer are consumable supplies that should be replaced by the user. When either of them needs replacement, inquire of the dealer or our distributor about details of purchase.

Pert name	Pert No.	Remarks
Main and sub prism unit	RE-11100	
Desiccant	RE-8100	
Contact liquid, monobromonaphthalene	RE-1196	nD ≒ 1.65, 4mL in bottle
Contact liquid, nD1.78	RE-1199	nD ≒ 1.78, 4mL in bottle
Measuring set for film	RE-1581	
Polarizing eyepiece	RE-1146	Measurement of double refraction
Tube band	RE-8507	Heat resistance: Up to 150℃ Unit quantity: 10 tube bands in a set
Camera adapter for DR-A1, DR-M Series	RE-19401	

2. Check and replacement of the consumable supplies

⚠ CAUTION

- When replacing the prism assembly, be sure to switch off the power switch of the DR-A1-Plus and to disconnect the power cable of the AC adapter from the mains AC outlet beforehand.
- 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.
- In the case the instrument is replaced with a circulating constant temperature bath, drain out water from tubes and disconnect the tube connected to the prism section from the nozzle in the side of the prism replacement.
- Make sure to replace the prism with a genuine prism as specified by ATAGO.

(1) Prism

* The prism of the DR-A1-Plus is replaced as a prism assembly composed of the main prism and the secondary prism.

①While holding the prism assembly firmly, remove three screws fastening the prism assembly with an Allen (hexagon headed) wrench supplied with the prism assembly for detaching/attaching it. Then, remove the prism and an O-ring (Fig. 12-1).

Note: When removing screws and the prism assembly, carefully hold the prism assembly by hand because it is considerably heavy.

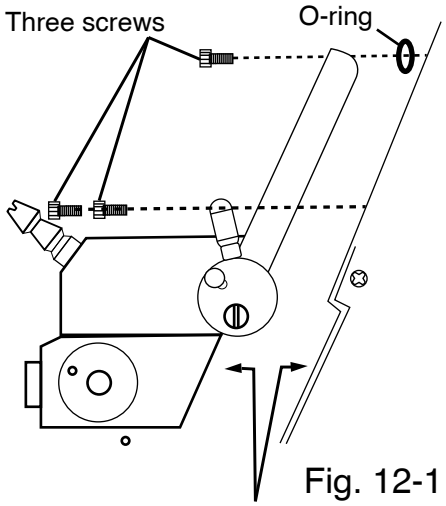


Fig. 12-1

②Put new O-rings on the three tapped holes on the DR-A1-Plus respectively, and set the prism assembly in place and fasten it to the DR-A1-Plus with the three screws while carefully holding it by hand.

③That is all for replacement of the prism assembly. Before starting measurement with the new prism assembly, perform calibration without fail (refer to Page 18).

(2) Replacement of 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.

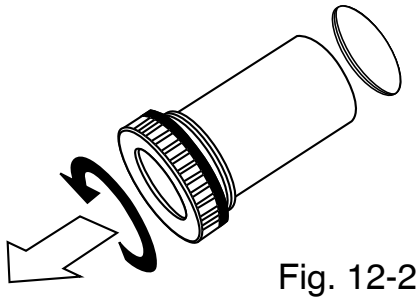


Fig. 12-2

①Unscrew the desiccant case from the main unit (Figure 12-2).

②Turn the cap of the desiccant case counterclockwise to remove and empty all particles of the desiccant from the case (Figure 12-3).

Note: Remove the cap with care to prevent loss of the packing.

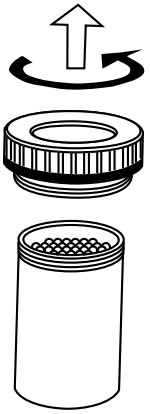


Fig. 12-3

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

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

(3) Discoloration or "Burning" of the Prism

Discoloration or burning may appear on the 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.

Pert name	Pert No.
Polishing Powder	RE-99402

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 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.

13. Explanation of refractive index and Brix percent

(1) Temperature compensation

Since refractive index of even the same matter varies depending on temperature, measurement of the same liquid with the refractometer brings a different result every time the sample temperature changes.
In the Brix% mode, DR-A1-Plus automatically compensates temperature change according to the temperature at the surface of the prism by the built-in microcomputer, therefore, indicated values are always the same as measured at 20℃ (when sample temperature is 5 to 50℃).

(2) Relation between Brix value (%) and refractive index (nD)

The following table shows relation between Brix value (%) and refractive index (nD) for reference.

— Relationship between Brix value (%) 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	96	1.5349
17	1.35891	37	1.39409	57	1.43520	77	1.48295	97	1.5379
18	1.36054	38	1.39600	58	1.43743	78	1.48552	98	1.5408
19	1.36218	39	1.39792	59	1.43967	79	1.48811	99	1.5438
								100	1.5469

Note:
Refractive index values for Brix 0 to 85% in the above table have been officially determined by ICUMSA (international Committee of Uniform Method of Sugar Analysis held in 1974). Further, refractive index values for Brix 85 to 100% in the above table have been used in the scale of ATAGO Abbe Refractometers for many years, and the values approximately correpond to the refractive index values for Brix 85 to 100% in the reference table which ICUMSA announced in 1994.

14. 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℃.

Temperature (℃)	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

15. Specifications of DR-A1-Plus

Measurement range	Reractive index (nD) : 1.3000 to 1.7100 Brix (%) : 0.0 to 100.0% (Automatic temperature compensation is executed at 5℃ to 50℃)
Minimum indication	Refractive index (nD) : 0.0001 Brix : 0.1%
Measurement accuracy	Refractive index (nD) : ±0.0002 Brix (%) : ±0.1%
Measurement temperature range	5 to 50℃ (at unit of 0.1℃)
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℃. ▪ 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).
Indications	Refractive index (nD) or Brix (%) and temperature (℃)
Display	LCD
Output terminal	For printer:DP-63(C)(optional) RS-232C
Power supply	With AC adapter AD-13 (100 to 240V (50/60Hz) AC input)
Power consumption	16VA
Dimensions (Main unit)	13(W) × 29(D) × 31(H)cm
Weight (Main unit)	6.0kg

16. Repair and warranty

The Digital Refractometer DR-A1-Plus is a complicated precision electronic instrument consisting of optical (prism and objective lens) and electronic parts. Since light and electricity are combined in the operation of this instrument, their mutual actions may make it difficult to isolate operational problems.
For this reason, repair and adjustment can be complecated and each serviceman is required to have special knowledge of optics and electrical engineering.
Do not disassemble or perform 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 technology 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 technology course at our company and has opened and tampered 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 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 modefications 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 DR-A1-Plus 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 service 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 DR-A1-Plus.

17. ATAGO CO.,LTD. Service Center

ATAGO has Authorized Service Centers around the world. Below is the list of countries where you can find an ATAGO Authorized Service Center. If your ATAGO instrument requires servicing please contact ATAGO at the following e-mail address.

overseas@atago.net

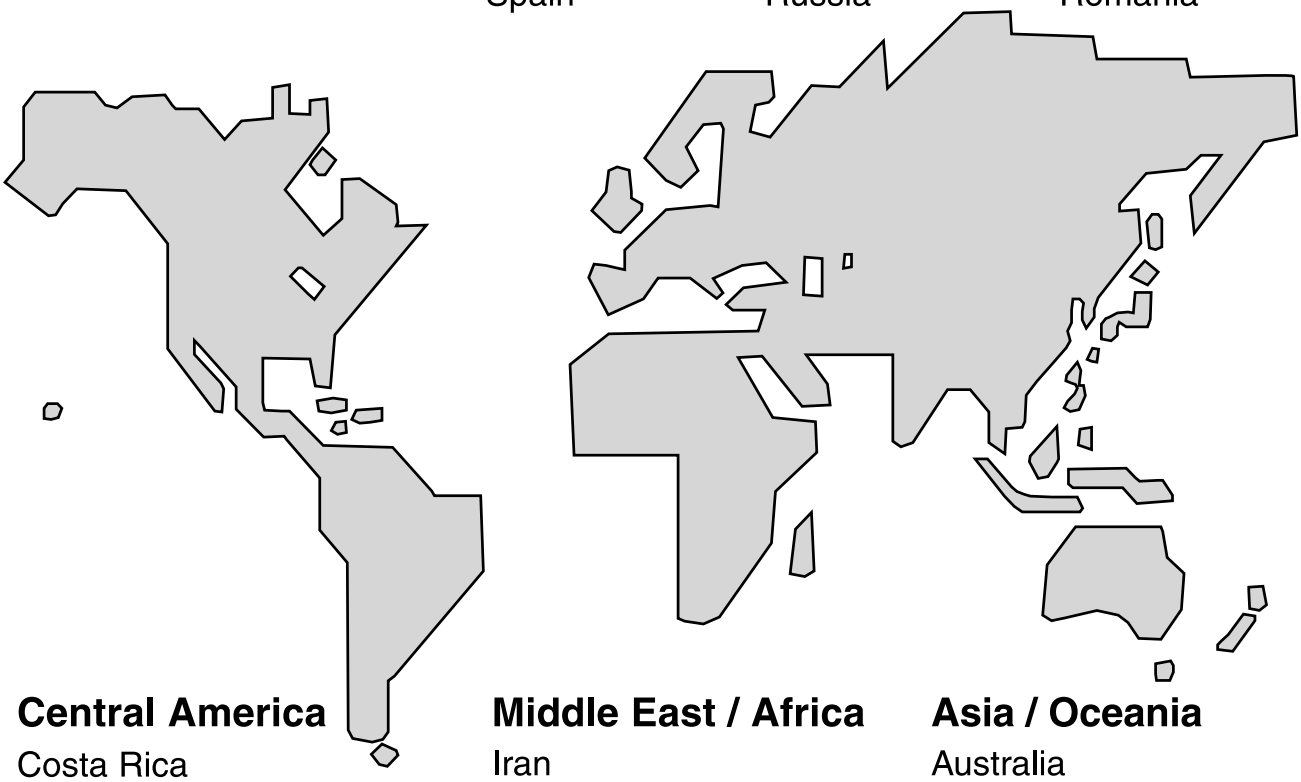
Please provide your company name, address and telephone number so that we can direct your inquiry to the Authorized Service Center nearest you. The Authorized Service Center in your area will contact you within 1 to 2 business days.

North America

Canada
U.S.A.
Mexico

Europe

Netherlands
Italy
Germany
France
Spain
U.K.
Belgium
Poland
Greece
Russia
Belarus
Ukraine
Serbia
Croatia
Romania



Central America

Costa Rica
El Salvador
Guatemala
Panama

South America

Argentina
Bolivia
Brazil
Colombia
Chile
Ecuador
Paraguay
Peru
Uruguay

Middle East / Africa

Iran
Turkey
Saudi Arabia
Israel
Lebanon
South Africa
Egypt

Asia / Oceania

Australia
China
India
Thailand
Korea
Taiwan
Indonesia
Malaysia
Singapore
Philippines
Bangladesh
Pakistan
Vietnam

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ATAGO INDIA Instruments Pvt. Ltd.
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ATAGO THAILAND Co., Ltd.
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ATAGO BRASIL Ltda.
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ATAGO ITALIA s.r.l.
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ATAGO RUSSIA Ltd.
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