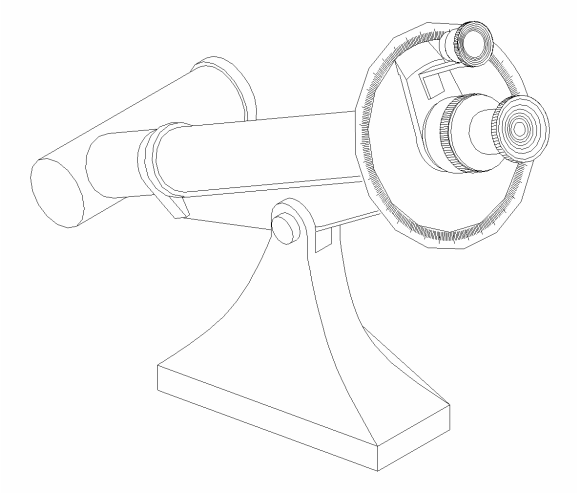
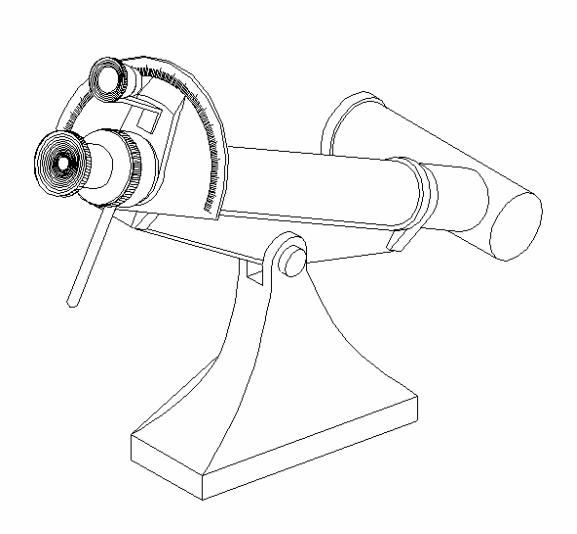
PolyScience





# Instruction Manual

# Polarimeter
# SR-6

110-065
1/04

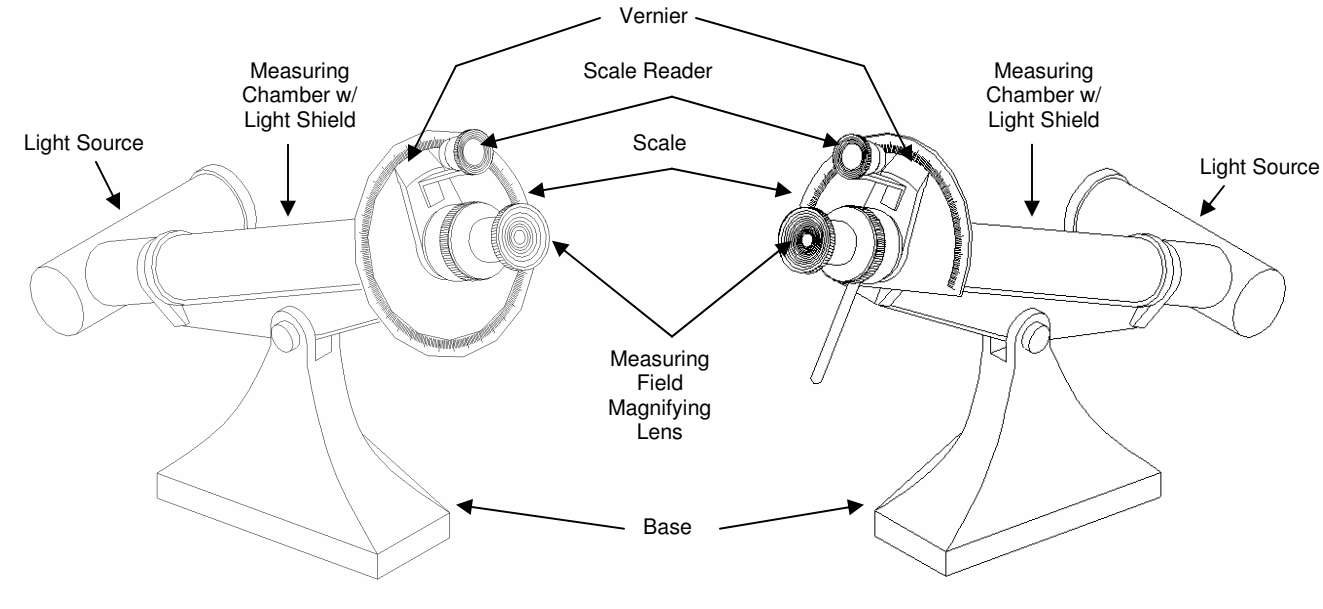
# Polarimeter SR-6

## Contents

# General Description

The SR-6 Polarimeter is available in two models.

- Half Circle, with a half circle scale, (0 to 90° right and left)
- Full Circle, with a full circle scale, (0 to 180° right to left)

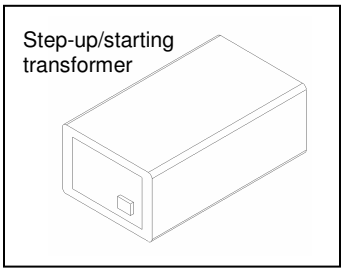



Both models have a vernier which is read with the aid of a magnifying lens. The vernier is turned to give readings in degrees of angle to 0.1°. Intermediate values may be interpolated.

Two light sources are available with the SR-6:

1. A filament bulb lighting unit, 6V, 2.4 watts.
   The filament bulb in combination with a built-in orange filter is adequate for measuring substances rotating the light beam by approximately 10°. The filament bulb model will suffice for diabetic tests. To use this unit, simply plug it into a wall outlet. No warm-up time is required.

2. A monochromatic lamp lighting unit.
   The lamp in combination with a built-in orange filter gives monochromatic light, (589mu), essential for measurements of substantial rotation and for highly precise measurements. The lamp model comes with a step-up/starting transformer. To use this unit, first plug the polalrimeter into the transformer and then plug the transformer into an outlet of the correct voltage.

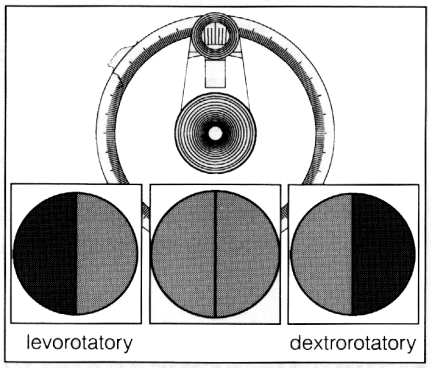



**Note:** The transformer has an internal switch for either 120V or 240V operation. The unit is turned on via the ON/OFF switch on the transformer. By looking through the measuring field or by removing the lamp unit, one can check that the lamp is lit.

## Measuring Procedure

1. Turn the vernier so that the zero (0) is at the zero (0) of the circular scale.
2. Adjust the magnifying lens of the measuring field so that the dividing line between the half circles is in focus. The half shadows should appear in equal brightness. The point of equal brightness of the half circles may not be exactly the zero point of the 0.
3. Insert a filled measuring tube into the measuring chamber with the expanded end of the tube up. To eliminate room light, rotate the light shield over the measuring chamber.

   If the darker half shadow is to the right, then the test substance is **dextrorotatory** (rotates the light beam to the right). A darker left shadow indicates a ***levorotatory*** substance (rotates the light beam to the left).




4. Turn the vernier in the same direction as the rotation until both half shadows appear in equal brightness. The degree of rotation is then read off the circular scale. Usually three of four measurements are made from which a mean value is used.

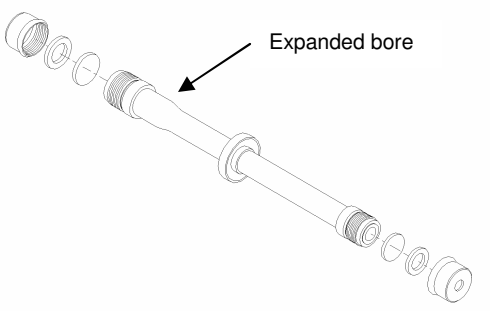
**Note:** If the vernier is turned 90° to the right or left of the obtained value, the half circle will appear inn equal illumination, but the field will be much brighter. These values would be either 90° too large or small.

## Measuring Tubes

Conventional measuring tubes of different lengths are available for use with the SR-6 (50, 95.04, 100, 150.4, 190.09 and 100mm). The most common tube for testing is the 190.09mm measuring tube. The upper end of the tube has an expanded bore to collect air bubbles which could disturb measurements.

## Filling the Measuring Tube

One end of the tube has a smaller diameter, the other end has an expanded bore.




Check that the cap on the expanded bore end is secure but not too tight. Remove the cap from the smaller diameter end. A glass cover disc and a rubber gasket (ring) should be in both caps.

Fill the tube completely, carefully avoiding the creation of air bubbles. When the tube is filled, slide the clean and dry glass cover disc from the side of the tube across the opening.

With a dry gasket in the cap, close this end of the tube securely but not too tight. In order to keep the instrument in good working condition, it is essential that the tube is never inserted wet into the measuring chamber, There should be no drops on the outside of the glass cover discs or the outside wall or the tube. A dry cloth may be used to wipe off the tube or cover discs.

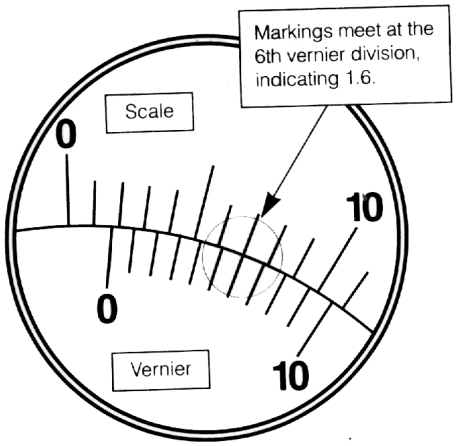
The measuring tube should not be held in a warm hand for long periods of time, since this may cause streaking within the liquid and thus inhibit brightness. The dry tube is inserted into the measuring chamber with the broader end up.

## Reading the SR-6 Vernier

After the tube is placed in the measuring chamber, and the light shield is closed, look into the magnifying lens. Rotate the vernier until both half circles are equal brightness.

Look into the scale reader for degree reading. Line up the vernier zero (0) to the upper scale and note the reading to the nearest degree for a more precise reading, the vernier will indicate tenths of degrees.

**Example.** In this example, the vernier zero (0) falls between one and two. For the most precise reading, the sixth division of both the scale and the vernier match exactly. Therefore, the precise reading is one and six tenths **(1.6°).**



View through the scale reader

## Rotation Determinations with the SR-6

The measurement of the rotary power of an optically active substance is the specific rotation (∝) which is referred to sodium light (D-line) and the temperature of 20°C:(∝) 20D. Rotations to the right are indicated by (+), rotations to the left are indicated by (-).

The following terms refer to a polarimeter with a graduated circle, as the **SR-6:**

(∝) – specific rotary power.

∝ - measured angle of rotation in degrees of a circle. [1]

1 – length of the tube in decimeters (1 dm = 10 cm = 100mm).

Rotation Determinations with the sr-6 (cont.)

d – density of liquid at a temperature of 1°C (referring to water of 4°C as standard)

c – concentration, i.e., the grams of optically active ingredients in 100cc of solution.

P – percentage of an optically active ingredient.

Q – weight of this measured ingredient in grams.

The praxis of optical saccharimetry is usually concerned with the determination of the concentration “c” of sugar solutions, the grams of sugar in 100cc solution, or the percentage “P”, the grams of sugar in 100 grams of a sugar containing substance.

[1] **The conversion of degrees “Ventzke” to angle degrees**. Some books refer to degrees “Ventzke”. Indicated below are the calculation factors for converting degrees “Ventzke” into angle degrees and vice versa.
1 degree “Vertzke” = 0.3469 angle degrees 1 angle degree = 2.8827 degree “Ventzke”

# Examples and Solutions to Polarimetric Problems:

Frequent polarimemtric determinations include:
1. the sugar in beets or in cane
2. the glucose in diabetic urine
3. the determination of lactose or maltose
4. the examination of volative oils, alkaloids, etc. for the genuineness or origin
5. the identification of some optically active drugs

The following formulas apply to polarimetric determinations:

**1.** $(\propto) = \frac{100}{1 \times c} \times \propto$ **2.** $c = \frac{100}{1 \times (\propto)} \times \propto$ **3.** $\propto = \frac{c \times 1}{100} \times (\propto)$

Therefore, values that can be obtained through polarimetry are:
1. The specific rotary power (∝) and the kind of active ingredient, if the concentration is known and the angle of rotation has been measured.

   **Example 1.** Take from the substance to be determined 4g, add water up to 100cc solution, polarization in the 1dm (100mm) measuring tube gives +2.65°.

   Solving for the specific rotary power:

   **1.** $(\propto) = \frac{100}{1 \times c} \times \propto$ $(\propto) = \frac{100}{1 \times 4} \times 2.65 = 66.25$

   Since the calculated value (∝) is very close to the known specific rotary power of Cane sugar (66.5), there must be cane sugar in this sample.

   **Example 2.** Glucose in diabetic urine,

   **1.** $(\propto) = \frac{100}{1 \times c} \times \propto$ $(\propto) = 52.80$ $(\propto) = \frac{100}{1 \times 52.80} \times \propto$

   Results if urine is polarized in:
   2dm tube: c = 0.947 x ∝
   1.9009dm tube: c = ∝
   0.9594dm tube: c= 2 x ∝
   In the 1.9009 dm tube ∝ = 4.8°, the concentration of glucose is 4.8%

   **Caution:** If the urine contains protein, the precautions mentioned in the following, More complete urinalysis discussion should be taken into consideration.

2. The concentration “c” from the measured angle ∝ if the mature of the substance and its specific rotary power (∝)are known.

   **Example.** A cane sugar solution is polarized in the 2 dm (200 mm) tube and shows ∝ = +10°. The specific rotary power (∝) of cane sugar is known to be +66.5. Therefore, to determine the concentration “c”.

   **2.** $c = \frac{100}{1 \times (\propto)} \times \propto$ $c = \frac{100}{1 \times 66.5} \times 10 = 0.752 \times 10 = 7.52$

   This means that this solution of 100 cc contains 7.52 grams of cane sugar.

If the 150.4 mm measuring tube is used, the degrees of circle read off the scale will equal directly the concentration (percentage) of a cane sugar solution, e.g. if the angle of rotation $\propto = 4.6°$, then 100 cc of a water solution contains 4.6 grams of cane sugar.

**Remarks**

1. Fresh sugar solutions show an unstable rotary power. A constant value of rotation can be obtained only after 6 to 24 hours, depending on the kind of sugar. However, constant values can be obtained within a few minutes by either boiling or by adding a few drop of ammonia. Before polarizing, the solution should be cooled to 20°C. The loss of water caused by boiling must be compensated for by adding a few drops again.

2. Fermentation may dissipate the sugar in old sugar solutions.

# Urinalysis for Glucose and Protein

Before making a glucose and/or protein determination:

1. Examine the urine for clearness. If the urine is very cloudy or not clear, it should be filtered.
2. If the 190.09 mm measuring tube is used and the dividing line of the half shadows cannot be clearly observed, then the 95.04 mm reassuring tube should be used. The shorter 95.04mm tube results in a much brighter “picture”. However, when using the 95.04 mm tube, all test results must be multiplied by 2.
3. If the urine is so dark that even the short tube does not give good results, then the urine must be brightened. There are four different methods for brightening urine:

   a – Add 10cc or an aqueous solution of lead acetate to 100cc of urine and filter This liquid. When using this method, the test result must be multiplied by 1.1 if The 190.09 mm tube is used. If the 95.04 mm tube is used, the result must be Multiplied by 2.2.

   b – Add just a little bit of lead acetate to the urine, shake in a bottle and filter.

   c – Shake the urine with a bit of diatomaceous earth and filter.

   d –Shake the urine with a bit of animal charcoal and filter

   *Methods b, c, and d, do not require a correction of the test result.*

The test for sugar and protein content begins with the measuring tube in the measuring chamber. Turn the vernier until both half shadows have exactly the same coloring and brightness. The degrees of rotation are read off the scale.

Since protein solutions rotate light to the left by as much as sugar solutions of the same concentration rotate light to the right, a second measurement is needed after the protein has been removed.

**To remove protein.** Boil 100 cc of urine and add diluted acetic acid until the urine is acidified and the protein is separated as a flocculent precipitate.

Filter and wash the filtrate and dilute it again to 100 cc. Once the protein has been removed, make second measurement.

Using the 109.09 mm measuring tube, the degree value of the second measurement corresponds directly to the percentage of sugar in the urine. The difference between the first and second measurement gives the protein content[2].

When using the 190.09 mm measuring tube:

- If no protein is present in the urine, the only one measurement is required for sugar content. The value obtained equals the percent of sugar in the urine.
- If protein is present in the sample, then two measurements are required to measure both protein and sugar content. Measurement one is taken before removing the protein, measurement two is taken after the protein has been removed. The protein content is the difference between measurement one and two. Measurement two will always give the true sugar content.

Care should be taken when determining the difference between measurements one and two. Measurement two will always give a zero or right (+) rotation, but measurement one may result in either a right (+) or a left (-) rotation. Therefore, when subtracting measurement one from two, it is necessary to consider the (+) or (-), according to algebraic rules.

Another simpler method of calculating for protein and sugar content:

1 If measurement one is left (-) and measurement two is zero or right (+), then: sugar content = measurement two and protein content = measurement one + measurement two.

2 If measurement one is zero or right (+) and measurement two is right (+), then: sugar content = measurement two and protein content = measurement two – measurement one.

If the urine was decolorized with acetic acid, then the obtained result must be multiplied by 1.1 (one tenth of result added). If the 95.04 mm tube is used, the results must be multiplied by 2, or 2.2 if the urine was decolorized by acetic acid.

# Analysis of Volatile Oils

$$(\propto) = \frac{\propto}{1 \times d} \quad \propto = 1 \times d \times (\propto)$$

These oils are polarized in the 1 dm (100 mm) tube, The measured degrees of rotation is usually considered as the characteristic of the oil. Normally, the specific rotation $\underline{\propto}$ is not calculated, since the literature on volatile oils refers only to the degree of a rotation in a 1 dm tube, while other substances are referred to by the specific rotary power.

The optical rotation of a volatile oil varies with the part of the plant from which it comes and the method of extraction. However, limit values are known for many oils, e.g. Oleum citri + 59° to + 67°in the 1 dm tube, Oleum carvi +70° to 85° in the 1 dm tube.

Oil measurements in the 0.5 dm tube are multiplied by 2, measurements in the 0.2 dm tube are multiplied by 5, and the measurements in the 2 dm tube are divided by 2

[2] Since the 190.09 mm measuring tube is not a special tube for protein measurements, the exact protein value is obtained by deducting 10%.

# Analysis of Milk

The determination of lactose is easier and faster by polarimetry than by other chemical method.

**Clearing.** Add 7.5 cc of a 20% sulfuric acid and 7.5 cc of a mercury iodide solution to 50 cc of milk. Filter, wash and fill with water to 100 cc.

The mercury iodide solution can be prepared by dissolving 40 grams of potassium iodide in 200cc or water, adding 50 grams of mercury iodide, filling solution up to 500cc with water and filtering.

### Lactose Determination

50cc of milk is cleared, filtered washed and then filled to 100cc with water. The lactose content in 100 cc of milk = c grams, polarized at 17.5° (the measured ∝°). Then in the 200 mm tube, c = 1.9037 x ∝.

Because of the precipitation volume, the values obtained have to be multiplied by 0.94 for whole milk and by 0.97 for skimmed milk. Cow's milk contains approximately 4.5 to 5% lactose.

# Analysis of Wine

Rotations to the right may be caused by

1. The addition of artificial dextrose either before of after fermentation.
2. The addition of cane sugar after fermentation.

Rotations to the left indicate a natural wine.

The percentage "P" of pure cane sugar in a solid, a sugar containing substance from which "Q" grams have been dissolved to 100cc solution and polarized in the 2 dm tube, can be determined by the following proportion.

Q: 0.752 ∝ = 100:P

0.752 results from $\frac{100}{1\times(\propto)}$

where (∝) + 66.5 and 1 = 2

From this the following has been derived for the praxis

solution is 100 cc. Measured degree of rotation = ∝° at 20°C

If Q = 26 grams (usual standard weight for cane sugar in saccharimetry), then P = 288∝, as measured in the 200 mm tube, and P = 3∝, as measured in the 190.09 tube. This means that 3∝% sugar is contained in the solid substance.

If Q = 13 grams (half the standard weight), then P = 6∝ as measured in the 190.09 tube.

If Q = 25 grams, then P = 4∝, as measured in the 150.4 mm tube.

In general for Q grams of substance in 100 cc water:

$P=\frac{75.2}{Q}\times\propto$ , with 200 mm tube

$P = \frac{150.4}{Q} \times \propto$ , with 100 mm tube.

$P = \frac{100}{Q} \times \propto$ , with 150.4 mm tube.

Q will not necessarily be 13.25 or 26 grams. As illustrated above, special length tubes in connection with certain qualities of substances offer simple and easy calculation factors.

## Analysis for Sugar Content in Beets

This test should be polarized in the 190.09 mm tube.

Add 177 cc of an aqueous solution of basic lead acetate (25cc to 1 liter of water) to 26 grams of beet pulp and heat in a covered container for 30 minutes as approximately 75°C. After cooling down to 20°C stir and filter.

**Example.** If the measured ∝ = 2.3°, then P= 6 x 2.3 = 13.8. The beets have 13.8% sugar.

*If the raffinose content is to be considered, refer to the method for this determination at the end of this manual*.

## Analysis for Sugar Content in Chocolate

Moisten approximately 10 grams of chocolate with a bit of alcohol in order to facilitate the subsequent dissolving in water.

Add approximately 30 cc of water and heat for 10 to 15 minutes on a water bath. Filter while hot and wash the residue with hot water.

After clearing the filtrate with approximately 5 cc of an aqueous solution of basic lead acetate, have it stand for 15 minutes. If necessary, add a few drops of aluminum hydroxide and fill up to 100cc with water.

When using the 150.4mm tube: p = $\frac{100 \times \propto}{}$ If Q – 10, then P = 10 x ∝

**Example.** If the measured ∝ = 4°, then P = 40. Therefore, the chocolate contains 40% sugar.

## Analysis of Food

Often foods contain mixed, optically active substances, such as different kinds of sugar, starch and dextrin. For determining the cane sugar content in active substances like jams, jellies, fruit juices, syrups, etc. the polarimetric method is easier than the chemical determination although it is necessary to invert the cane sugar.

**Invert Sugar.** Diluted acids as e.g. oxalic acid or certain ferments in fresh fruit juices, split the cane sugar (saccharose) into two ever parts:

- dextrose, which results in a rotation to the right.
- fruit sugar (levulose) which results in a rotation to the left.

The mixture of these two kinds of sugar is called “invert sugar”. Since levulose results in a left rotation, which is greater than the right rotation of the dextrose, all invert sugars show a rotation to the left.

Inversion is done to determine the cane sugar if the substance is a mixture of active substances besides cane sugar.

Therefore, two measurements are required:

- the angle of rotation P before the inversion
- the angle of rotation J after the inversion.

With these two measurements, it becomes possible to determine the cane sugar content according to the formula mentioned on the next page.

## Inversion Procedure

Dissolve 13 grams of the substance in 75 cc of water.

Add 5 cc of hydrochloric acid, 22.5°. Be (specific gravity 1.185), shake, and in a water bath that is preheated to 70°C, heat the test sample until it has reached a temperature of 68 to 79°.

Allow the substance to heat to 68 to 70°C for five minutes. It is important that the flask is immersed to the neck to insure a uniform heating. The liquid is inverted now and should be cooled fast down to 25° by suspending the flask in cold water.

Fill up again to 100cc with distilled water, mix and filter. Do not clear with an aqueous solution of basic lead acetate since this influences the rotation of invert sugar. If necessary, clear with animal charcoal.

If determinations are done with a substance quantity different than 13 grams, then the acid quantity necessary for the inversion should be changed accordingly. Different methods of inversion (as for yeast) may be done as well.

For determining the cane sugar (saccharose) in mixed sugar, containing substances, e.g. jams, fruit juices, etc, two measurements are necessary, before and after inversion.

Q grams of mixed sugar containing substance, dissolved in 100cc in water, polarized in the 2dm tube at a temperature of 20°C:

P = angle of rotation before the inversion

J = angle of rotation after inversion

(P to J) = the difference between these two measurements.

Cane sugar content Z of the substance in percent:

$Z = \frac{57}{Q}$ x (P to J), If Q = 28.5 rams, then Z = 2 x (P to J).

The quantity Q may be varied. However, it is not advisable to go over 30 grams, otherwise the value for the specific rotation in the formula is no longer applicable. Also, if Q is too great, the quantity of insoluble parts in the substance may disturb the test. Often the weight of 13 grams is used in the sugar industry as Q. This may disturb the test. Often the weight of 13 grams is used in the sugar industry as Q. This weight is half the standard weight. In this case,

$Z = \frac{57}{13}$ x (P to J) = 4.34 x (P to J).

This factor of 4.34 varied slightly according to the cane sugar content in 100cc.

| At | 1% | 5% | 10% | 13% | 20% |
|---|---|---|---|---|---|
| | 4.376 | 4.366 | 4.356 | 4.348 | 4.334 |

In order to obtain very accurate values:

1. Calculate with the above mentioned formula which will result in a Z, indicating the concentration of the sugar solution as e.g. 5 grams per 100cc.
2. Calculate once more, but not with the general value 4.34 but rather with the actual factor for 5% which is 4.366.

**Example.** Q = 10 rams honey, measured in the 2dm tube, P = +0.8°.
Measured in the 2dm tube, J = -0.4°.
Therefore, (P to J) = 1.2,

$Z = \frac{57}{13}$ x 1.2 = 6.84%

A larger quantity of substance would result in the same Z value since both the angle of rotation and the quantity value Q are larger.

It is not possible to determine through polarimetry the exact quantity of cane sugar that was originally added to fruit juices because the fruit acids may have already inverted a part of this cane sugar.

## Substances Which Contain Raffinose

The formula $Z = \frac{57}{13}$ x (P to J)

is not valid if the substance to be tested contains raffinose besides cane sugar, as for sugar beets.

If calculated with Q = 13 grams, dissolved to 100cc and polarized in the 2dm tube, the following formulas are applicable:

Z (cane sugar in %) $= \frac{0.5124 \times P - J}{0.1454}$ if J is right rotating

or $= \frac{0.5124 \times P - J}{0.1454}$ if J is left rotating

R (raffinose in %) $= \frac{0.576 \times P - Z}{0.1852}$

**Example.** Measured P = +13.3°, measured J = 0.5

Therefore,

Z = $\frac{(0.5124 \times 13.3) + 0.5}{0.1454}$ =50.3

R = $\frac{(0.576 \times 13.3) - 50.3}{0.1852}$ =14.2

## Analysis of Syrup

Syrups are usually a mixture of starch, sugar syrups, containing glucose, maltose, dextrin.

(∝) = +109°, before inversion. (∝) = -11.07°, after inversion of cane sugar syrup.

Invert 10 grams of the mixed syrup to be tested, fill to 100cc, an2dm tube. Result is a right rotation ∝°.

(∝) of inverted syrup = $\frac{100}{2\times10}$ x ∝ = 5 ∝

For the calculation, the following formula is applicable:

$P = \frac{(\propto +11.07)\times100}{109+11.07}$ if Q = 10 grams

If Q = 10 grams, $P = \frac{(5\propto +11.07)\times100}{109+11.07}$

**Example.**

∝ = +3°, so (∝) = + 15°, and $P = \frac{(26.07)\times100}{120.07} = 21.7$

## Analysis of Flour

If polarized in the 2 dm tube, the starch content is 0.2725 in grain flour, and 0.2872 in potato flour.

## Service

Service facilities for these instruments are maintained at:

**PolyScience**
**Attention Service Department**
**6600 West Touhy Avenue**
**Niles, Il 60714-4588**
**Telephone 847 647-0611 Fax 847 647-1155**
**Toll free 800 229-7569**

**Do not** ship instruments or fragile parts without authorization. When shipment is made, be sure instrument is carefully packed and ship insured.

Constant Temperature Circulator and Baths, and Homogenizers are also available from PolyScience for possible use in the preparation of polarimetric substances. Write of call for information.

# Parts and Accessories

| Cat No | Description |
|---|---|
| 3-310413 | Model SR-6 Polarimeter with Halogen Lamp (Half circle scale, 0-90°right and left. |
| 3-310416 | Model SR-6 Polarimeter with Halogen Lamp (Full circle scale, 0-180° right and left. |
| 3-310502 | Measuring tube, 200 mm long, for general use |
| 3-310504 | Measuring tube 190.09mm long, for diabetic tests and glucose, scale reading =% |
| 3-310505 | Measuring Tube 150.4mm long, for cane and beet sugar, scale reading = % |
| 3-310507 | Measuring Tube, 100mm long, for general use |
| 3-310508 | Measuring Tube, 95.04mm long, for diabetic tests and glucose, scale reading x 2 = % |
| 3-310509 | Measuring Tube, 50mm long |
| 3-311303 | Glass cover discs for tube, 12 each |
| 3-311304 | Washer for tube, 12 each |
| 3-350703 | Sodium Lamp, serial #7924 and earlier. |
| 3-362602 | Filament Lamp, 6v/2.3w |
| 3-350508 | Step up/Starting transformer |
| 3-350705 | Halogen Lamp, derail #7925 and higher |
| 3-350706 | Selecting Filter, serial #7925 and higher |