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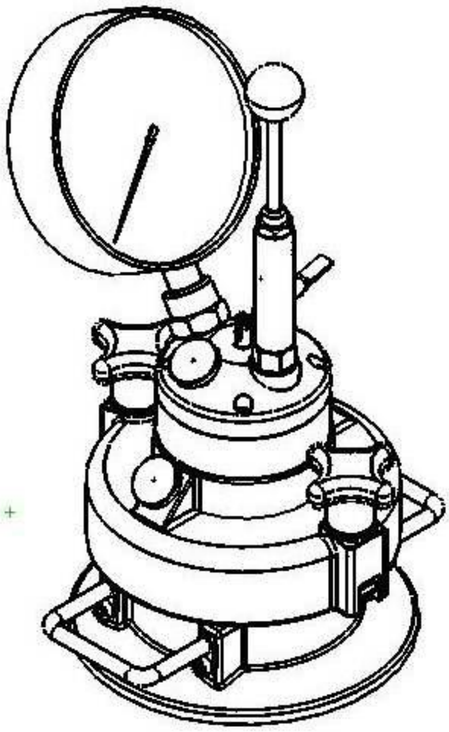
Operating Manual

Air Pycnometer, 1 Litre
Type 7306
Equipment Number: 253



Importance of this Operating Manual:
Do not place this machine into operation before you understand the function and position of all control features.

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Attachments:
Declaration of conformity
Spare-parts list
Exploded diagram and functional elements of the 1-litre manual Air Pycnometer
Sequence of operations; testing the device

1. Basic instructions

1.1 Pertinent standards and regulations

This Operational Manual contains the information required for operation of the product described here, for the purpose for which they have been designed. This Operational Manual is intended to be used only by technically qualified staff.
“Technically qualified staff” is defined as those persons who – as a result of their training; their experience; the instructions which they have received; as well as their knowledge of the relevant standards, regulations, accident-prevention regulations, and conditions under which the product will be operated in the company – have been authorized by the person responsible for the safety of the company facilities and staff to carry out the activities and actions required for operation of the equipment described below, and who can recognize and prevent any possible dangers arising from such operation (this definition of technically qualified staff has been provided in IEC 364).

The User must by all means observe the requirements and limit values, as well as all safety instructions, given in this Operational Manual. Any use of this device not in conformity with these stipulations shall be considered to be in violation of the use for which this system was intended. If this device must be operated under special conditions, or with special modes of operation, then this is authorized only after consultation with the manufacturer, and after obtaining his prior and express approval.

The Air Pycnometer method is a test procedure which measures the following soil-mechanics characteristics in relatively short time:

- Water content: w
- Grain density ρ_s

DIN 18125, Sheet 2, “Determination of Water Content by Fast Procedures,” describes how to measure the water content w.
The technical testing specifications for soils and rocks, TP BF-StB, Part B 3.3, published by the German Research Association for Roads and Transportation, describes measurement of the grain density ρs.
The Air Pycnometer, owing to its engineering design and simple operation, is especially well suited for use on construction sites.
This Operating Manual provides a detailed description of the conduct of testing and an evaluation of test results, as well as a description of the monitoring possibilities to assure the functionability of the device. The following instructions pertain to the testing of soil samples. They apply to the Air Pycnometer with a testing volume of 1,000 ml.

1.2 Purposes for which this device is not intended to be used

This Air Pycnometer is not intended to be used for construction materials that are different from those stated in Section 1.1 above.

1.3 Safety instructions

1.3.1 Obligations of the user

This Air Pycnometer has been designed and built in accordance with the state of the engineering art and with the accepted rules of good engineering practice. The use of this Air Pycnometer, however, can cause danger to the health and safety of the User and third parties. It can also cause damage to mechanical parts or to other objects of value.
The Operator of the Air Pycnometer is responsible to ensure that he or she does not endanger himself/herself or any other persons in the operation of this equipment. Only those persons who have received instruction in the operation of this Air Pycnometer are authorized to operate this device alone and under their own responsibility.
If there are any malfunctions or other trouble that could cause dangerous situations to arise in work with the Air Pycnometer, these difficulties must be corrected in all cases before working with the machine.

The Air Pycnometer may be used only:

- For the purposes for which it was intended
- If it is in completely satisfactory technical condition with regard to safety in operation.

If there are any malfunctions or other trouble that could cause dangerous situations to arise in work with the Air Pycnometer, these difficulties must be corrected in all cases before working with the machine.

1.3.2 Safety features

Protection of the hand ump during transport
To prevent damage to the hand pump during transport, screw down the pump rod. Use the round head with the thread to screw the pump rod into the upper part of the Air Pycnometer.

1.4 Receiving the system from the forwarding agent; transport
1.4.1 Receiving the system from the forwarding agent

When the system arrives from the forwarding agent, make an external inspection. If there are no visible damages or other shortcomings, accept the consignment from the freight forwarder (the package service or a haulage agent).

If there are no transport damages or other shortcomings, use the bill of delivery to check to make sure that the delivery is complete.

If you believe that transport damage may have taken place when you receive the equipment, or if you discover after you have accepted the delivery that damage has occurred, immediately make a report of this damage, with an exact description of the nature and the extent of the damage. Send this report to us immediately by fax. Important: Be sure not to make any changes or other alterations to the system as it has been delivered.

When we receive this report, we shall decide whether we can solve the difficulty by one of the following steps:

- Delivery to you of spare parts
- Sending a specialist fitter or mechanic to your company
- Asking for return of the system to us for replacement or repair.

1.4.2 Transport

The Air Pycnometer is delivered in suitable carton packing. Filling material is placed in the remaining empty spaces to prevent transport damages.

After being unpacked, use the handles to move the Air Pycnometer by hand to its place of use.

Store the Air Pycnometer in an upright position. Do not allow the Air Pycnometer to be subject to impacts or vibration that could harm the sensitive pressure gauge. Before transport, be sure to screw in the pump rod as described above.

The weight is approx. 5.9 kg.

1.5 Scope of delivery

Air Pycnometer

<u>*As options, at additional price:*</u>
Attachment ring for filling the meter
Transport container
Tamper and straightedge for striking off

If you request, we can deliver, as an option at extra cost, a calibration record for use as proof of monitoring of testing equipment. This can be important as part of your quality management system.

1.6 Description of the equipment

1 Test pot
2 Star handle
3 Correction valve for the air chamber
4 Air pump
5 Precision pressure gauge (accuracy class as per DIN 18 070)
6 Pressure equalization valve
7 Air chamber
8 Air-vent valve

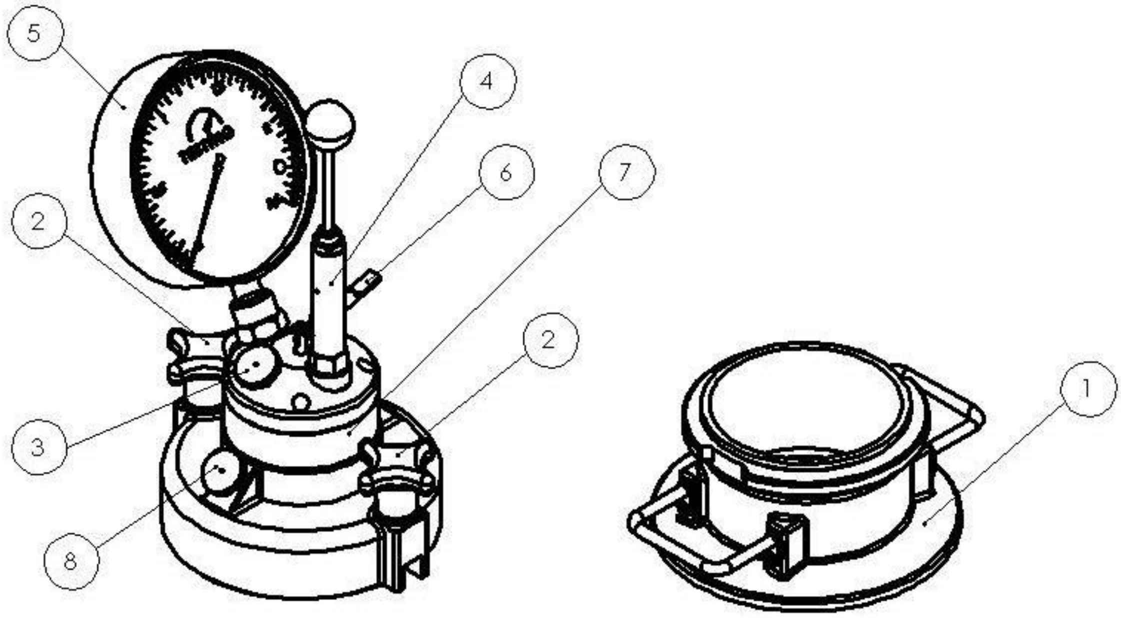

Fig. 1: Schematic diagram of the Air Pycnometer

2. Description of the measuring method

Fill the soil sample into the pressure-tight test pot (1). Operate the air pump (4) to build up an air pressure of approx. 2.35 bar in the air chamber (7). Now use the correction valve for the air chamber (3) to exactly regulate the air pressure to precisely 2.30 bar. Now operate the pressure equalization valve (6) to allow the excess pressure to pass through this valve into the test pot. A pressure between the test pot (1) and the air chamber (7) will now develop that represents an average between these vessels. Measure this pressure with the precision pressure gauge (5). Now use this pressure together with the nomographic charts provided with every Air Pycnometer to determine the volumes of the solid and liquid constituents of the soil sample. Use these volume results, the mass of the wet sample, and the known grain density to calculate the water content *w*.

3. Conduct of testing

First determine the mass m_K of the test pot. Then fill the sample into the test pot, one layer at a time. Use the tamper to thoroughly tamp down each layer by hand. The sample should fill the test pot, but only up to the top edge. Next, weigh the test pot with its sample (m_K + m). Now, carefully clean and slightly moisten the top edge of the test pot and the sealing ring. Make sure that the air-vent valve (8) is open. Place the upper part down onto the test pot. Now turn the upper part horizontally by 90 °, and use the two star handles (2) to screw the upper part down. The tension should be the same in the star handles. The star-shaped heads of these threaded fastenings have markings. When they are screwed down tight, the markings will be in the same position, pointing toward the front (i.e., toward the person who is making the adjustments). This is necessary to prevent fluctuation of the volume of the pot that could result from different tension in the threaded fastenings. Close valves (3) and (8). Use the air pump (4) to create a pressure of approx. 2.35 bar in the air chamber. Important: do **NOT** screw in the pump piston!
Carefully open the correction valve for the air chamber (3) and vertically knock against the pressure-gauge lens with the Plexiglas view-direction tube. Use the correction valve to precisely set a pressure of p_0 = 2.30 bar in the air chamber. Always be sure to make this precision correction **when the pressure is falling**. When you read off from the pointer of the pressure gauge, be sure to look through the Plexiglas view-direction tube that is permanently attached to the gauge lens. The enclosed nomographic chart no. 1 has been prepared for the necessary evaluation in connection with this pressure of p_0 = 2.30 bar.
Next, close the correction valve for the air chamber (3). Carefully open the pressure equalization valve (6) to allow the air pressure to equalize between the air chamber and the test pot. You can tell that the pressure has been completely equalized when you knock with the Plexiglas view-direction tube onto the pressure gauge while valve (6) is open, and the pressure reading remains constant. While leaving the pressure equalization valve (6) open, then enter the final, resulting air pressure p_1, as shown by the precision pressure gauge, into the record of testing.
If pressure equalization does not take place within 5 to 10 seconds, and if the pressure continues to decrease, then the measuring device has a leak. If this is the case, open the air-vent valve (8) of the test pot. Then take off the cover to the pot and clean the top edge of the test pot. Also clean the rubber ring and the screw valves. Perform a new test. If

pressure equalization again does not take place within 5 to 10 seconds, and if the pressure continues to decrease as before, then check the entire Air Pycnometer for leaks. See the instructions in Section 10 of this Operating Manual.
After the first measurement, open the air-vent valve (8) of the test pot to vent the soil sample. To perform the second measurement, now use the air pump (4) to pump up the pressure in the air chamber (7) to exactly 2.35 bar. Close the air-vent valve (8). Follow the instructions given above for the first measurement to regulate the pressure to 2.30 bar by using the correction valve for the air chamber (3). Continue the second measurement by following the instructions given above. It is necessary to perform three measurement procedures as described above. Record the readings as p_1, p_2, and p_3. Now determine the mean (average) value p for purposes of total evaluation. Now determine the volume by using nomographic chart no. 1.
After completing the measurements, open the air-vent valve (8) of the test pot. Unscrew the threaded connection, and lift off the upper part. Finally, thoroughly clean the test pot and the underside of the cover.

Important note:

Before testing, make sure that the temperature of the soil sample and the temperature of the Air Pycnometer are the same as the ambient air temperature. If these temperatures are different even by 1 °C, this can lead to pressure deviations in the two chambers, and to faulty results. See Section 14 of this Operating Manual.

4. Evaluation of the results for water content

4.1 Calculating the water content *w*

Calculation of the water content is based on the fact that a two-component mixture (soil and water) is located in the test pot. The measurement procedure determines the mass m and the volume V of this mixture. The components of the two-component mixture have their own specific weight ρ. The Air Pycnometer determines the total specific weight of both components, the so-called **water-saturated grain density** ρ_m. This water-saturated grain density results from the ratio of mixture of the soil and the water. The following equation gives the water-saturated grain density ρ_m:

$$\rho_m = \frac{m}{V} \text{ [g/cm}^3\text{]} \qquad (1)$$

Since the pressure has been equalized in the Air Pycnometer, it is not necessary to consider the content of air in the soil sample.

Use the following equation to calculate the water content *w* of the soil sample:

$$w = \frac{\rho_s - \rho_m}{\rho_s(\rho_m - 1)} \text{ x } 100 \text{ [\%]} \qquad (2)$$

ρ_s = grain density of the mineral share of the sample

4.2 Determination of the water content *w* by using nomographic chart no. 1

The enclosed **nomographic chart no. 1** enables determination of the water content of soils with a grain density ρ_s of 2.65 g/cm³ (for example, sands and gravelly sand). This is the basic reference grain density. For different densities, an adjustment factor will be necessary (see example below).
Determine the water content of the soil sample as follows:
Find the intersection of the mean value of the three pressure-gauge readings on the *x* axis, and find the mass m on the *y* axis. Draw a horizontal line from this point of intersection to the water-content plot. This new point of intersection will give the water content of the soil *w*, in per cent.
For every deviation of the grain density ρ_s by 0.01 g/cm³ from the reference value of 2.65 g/cm³, the water content must be adjusted by applying the adjustment factor of 0.25 %. See the example below.

Example:
If the grain density ρ_s is 2.69 g/cm³, then there will be an increase in water content *w* by approximately 4 x 0.25 % = approx. 1.0 %.

It is possible to use nomographic chart no. 1 to determine the **dry density** ρ_d, the **pore volume**, and the **air content** in soils samples that have been collected with a standardized sampling cylinder in accordance with DIN 18125-2, with diameter = 100 mm, height = 120 mm, and volume V = approx. ca. 850 cm³.
This makes it possible with a compacted sand subgrade (to take one example) to use only one measurement to continuously monitor the proctor density ρ_{Pr} and, as a result, the required degree of compression D_{Pr}. You can use nomographic chart no. 2 to determine the water content *w* of soils and soil mixtures with grain densities ρ_s from 2.50 to 3.20 g/cm³. If it is necessary to determine the water content in aggregate, you can use chart no. 2 to read off the water content *w* for the associated wet mass, along the line for the corresponding grain density ρ_s = 2.50 g/cm³. It is also possible to determine the water-cement ratio.
If you determine the water content *w* in the above-described manner, and if you find a water content of 6 % (for example) on the lower scale, this would mean that 60 litres of water are contained in 1,000 kg of wet aggregate. Note: Please remember that you read off the water content at the upper graduations between the ρ_s lines 2.80 g/cm³ and 2.70 g/cm³.
The graduation lines, as main graduations, pass through all ρ_s lines. Nomographic chart no. 2 provides the key for determination of the water content.

5. Determining the grain density ρ_s

The soil sample must be completely dry (oven temperature = 105 °C). Perform the test in accordance with the instructions under Section 3 above. The grain density ρ_s of the soil sample is calculated as follows:

$$\rho_s = \frac{m_t}{V} \text{ [g/cm}^3\text{]} \qquad (3)$$

Where:
m_t = the dry mass
V = volume of the sample
Chart no. 1 leads the user via the mean value of the pressure-gauge readings: i.e., vertically to the volume and then farther to the intersection with the dry mass of the material, then horizontally to the scale on the left margin with the scale divisions for grain density. Chart no. 2 has the scale for grain density a the right margin. The key for this data analysis is given in the upper section of chart no. 2.

Note:
This conduct of testing requires a high degree of measurement exactness and simultaneous checking of the measurement procedures with a reference volume. If the soil sample to be tested is delivered in earth-moist condition, then the test for grain density should take place on the earth-moist soil sample – with the water content determined only afterward by oven drying.

6. Additional remarks for improvement of the measurement exactness for determination of the volume

The greater the filling volume of the soil sample in the test pot of the Air Pycnometer, the greater the measuring exactness. When determining the grain density, the volume of the soil sample should not be under 800 cm³. Since a dried soil sample has a large pore volume, this pore volume must be filled by adding water (ρ = 1.0 g/cm³).

Procedure:

1. As an example, fill 300 g of water into the empty test pot. The water should have the same temperature as the soil sample. The fill in the dry material, while stirring, until the material reaches to approx. 3 mm below the top edge of the test pot. Now determine the mass m_t of the dry material. There are some powdery dry soils that cause a temperature rise when they dissolve in water. In such cases, check the temperature. Then perform the three individual measurements, and calculate the mean value for evaluation.

   As the evaluation example shows, the added 300 g of water must be subtracted from the volume and from the mass of the soil sample in the test pot.

2. When determining the grain density of construction materials, use only the following-described procedure, which includes the insertion of volume plates. This is because cements, for example chemically change upon addition of water and correspondingly

undergo a change in volume. Before filling the pot with the soil sample, place a reference volume (for example, 100 or 200 ml) into the empty test pot. The volume plates can be obtained from the manufacturer. Here also, the plate volume must be subtracted from the total volume.

3. If the soil to be tested has a stiff consistency, or a high consistency (for example, with extremely plastic clay), the Air Pycnometer procedure cannot detect the closed pores. In such cases, fill into the test pot a certain amount of water (for example, 300 g of water) with the same temperature as the soil sample. Then reduce the soil sample into small sizes and fill it into the test pot. Determine the total mass, and conduct the Air Pycnometer test as described in Section 3 above.

7. Checking the measuring accuracy

The Air Pycnometer delivered has been calibrated under the following conditions: the altitude of Berlin Germany, and exact maintenance of the same temperature in all parts of the Air Pycnometer. With use at other altitudes, however, the volume scale will not shift. In order to immediately check very important measurements at any time to make sure that the volume accuracy is correct, the following is possible:

a) A volume calibration set is available for use with your Air Pycnometer, and can be ordered from the company that makes the Air Pycnometer. This set consists of calibrated partial disks with the following sizes: 1 x 500, 4 x 100, 2 x 30, 1 x 20, 1 x 10, 2 x 5, 2 x 2, 2 x 1 cm³. Use this volume calibration set in a way similar to the use of a calibrated set of weights.

Example:
Tests made to determine the grain density of a soil sample provided the averaged reading of 1.052 bar. This corresponds to a volume of 668 ml in accordance with nomographic chart 1. This result was checked immediately by placing partial disks with a volume of 668 ml into the test pot. If this check measurement provides the result of 1.048 bar, for example, then the volume difference between 1.052 bar and 1.048 can be determined by means of chart 1. The difference of the volume variation must be compensated for by the partial disks. A check measurement should then give a pressure of 1.052 bar.

It is possible that the Air Pycnometer can give a false reading: for example, if the soil sample, the air, and the Air Pycnometer do not have the same temperature. In such a case, the volume calibration set can be used to immediately check the volume determination of the soil sample with a precision of 1 cm³ – and to correct this result. The volume calibration set must be a the same temperature as the Air Pycnometer and the ambient room temperature.

In all cases, it is important to ensure that the clamping bolts are in the correct position as indicated, that the Air Pycnometer absolutely has no leaks, and that the reading is made with the Plexiglas view-direction tube.

b) A volume check is also possible by filling with water that has been exactly weighed beforehand, and that is at exactly the correct temperature. See Section 13 for an exact description of this procedure.

8. Air Pycnometer measurements made on cylinder samples

The soil material taken from a standardized sampling cylinder – in accordance with DIN 18125-2 (i.e., diameter = 100 mm and height = 120 mm) – will fit into the test pot of the Air Pycnometer. Such standardized sampling cylinders have a volume of approx. 825 cm³. Use a slide calliper to determine the exact volume of the cylinder. Or, the cylinder volume can be determined from the weight of the cylinder divided by γ_{sr} (specific weight of the steel cylinder γ_{sr} is = 7.85). Fill the soil sample into the test pot and determine the mass m. After the Air Pycnometer test, the evaluation will provide the following for the soil sample, in accordance with Section 12.3: the water content, the wet soil density, the dry soil density, the pore volume, and the air content.

If the Proctor density ρ_{Pr} of a soil sample is known, then the Air Pycnometer can quickly and simply check the degree of compaction D_{Pr} on the construction site. The degree of compaction is calculated from the following equation:

$$\text{Degree of compaction } D_{Pr} = \frac{\text{Dry soil density } \rho_d}{\text{Proctor density } \rho_{Pr}} \qquad (4)$$

9. Determination of water content for the Proctor test

To make a Proctor test in accordance with DIN 18127, it is necessary to determine the water content of the soil sample by oven drying. To avoid long drying times, it is possible to quickly determine the water content with an Air Pycnometer on the construction site. Proceed as follows:

Place the soil sample, still moist from the earth, in layers in the Proctor vessel. Then carry out the water-content test as described in Section 3 here. This determines the initial water content for the Proctor test. Then add a slight amount of water and mix the soil well. Then conduct the second individual test.

Then conduct another water-content test in the Air Pycnometer. The line connecting the two points from the data obtained determines – by the rise or fall of this line – whether an additional mixture of water, or over-drying of the soil material is necessary before the third and (finally) the fourth individual tests – including the water-content test – can be performed. Here, a soil grain density of 21.65 g/cm³ is assumed as a basis. If the actual grain density is greater or less, the Proctor curve will – for example, with ρ_s = 2.69 g/cm³ – shift by 1.0 % on the water-content line of the chart.

10. Care of the Air Pycnometer

Measurement accuracy of the Air Pycnometer can be assured only if there are absolutely no leaks in the entire system. The air pump, the valves, and the connection between the test pot and the upper part must be absolutely tight.
It is important to immediately lock the piston of the air pump after the preliminary pressure of approx. 2.35 bar has been reached. If the pump valve should develop a leak, the system will prevent the pump piston from moving up and air from escaping from the upper part of the Air Pycnometer.
You can quickly and easily find a leak by pumping the Air Pycnometer up to approx. 2.0 bar, and immersing the Air Pycnometer in water up to the lower edge of the pressure gauge. Bubbles rising in the water will show the position of the leak.
To care for the Air Pycnometer, clean it and seal it with Vaseline. Take off the rubber rings (valves and rubber ring a the coupling interface) and apply Vaseline thinly all around the rings. Only the manufacturer may repair or seal the pressure gauge and the pressure-equalization valve. If you cannot repair the leaks by the methods shown above, the Air Pycnometer must be returned to the manufacturer for inspection.
To ensure great measuring accuracy in the Air Pycnometer measurement procedure, careful and professional care of the precision pressure gauge is very important.
After each measuring procedure, it is important to empty the test pot immediately and carefully clean the pot.

11. Adjustment of the pressure-gauge reading

The volume of the test pot and the reading of the pressure gauge can be influenced by the position of the clamping bolts. The rubber sealing ring between the upper part and the test pot allows adjustment by tightening or untightening of the two tightening bolts. First, the Air Pycnometer must be calibrated by a qualified specialist, who then prepares a volume scale. When this has been accomplished, the marking arrows and the number “1” on the neck of the tightening bolt (5) will point toward the front. After allowing all parts of the Air Pycnometer to reach the same temperature, a measurement check should be made before conduct of testing. This check is performed with the volume calibration set. If this measurement check reveals a discrepancy with respect to the calibration scales, then it is possible to slightly change the volume of the test pot by changing the position setting of the tightening bolts. If the bolts are changed in this way, their position must remain the same for all future tests.

Example: The pressure reading can be lower than the correct figure: e.g., with a volume of 600 ml, a reading of 0.780 bar is found instead of the reading 0.784, which would be correct from the nomographic chart. In such a case, it is possible to turn the clamping bolts to the right, to their next marking, in order to find a valid deviating marking-arrow position. In our example with 600 ml, it would be possible to achieve the correct pressure-gauge reading of 0.784. This adjustment is sufficient over the entire scale range of the nomographic tables, for water-content testing when the grain density of the soil is known.

12. Description of the analysis procedure (nomographic chart no. 1)

12.1 Determination of the water content

As shown in Fig. 2 below, enter the mean value of all pressure-gauge measurements on the *x* axis. Then draw a vertical line from this value upward to intersect the plot of the test mass (i.e., the sample weight). Then draw a horizontal line, parallel to the x axis to intersect the water-content plot. This intersection gives the water content in per cent. This value is referenced to the dry mass for a grain density of the mineral share of the soil sample of ρ_s = 2.65 g/cm³.

Water content *w* (in %)

Sample mass

Pressure-gauge reading

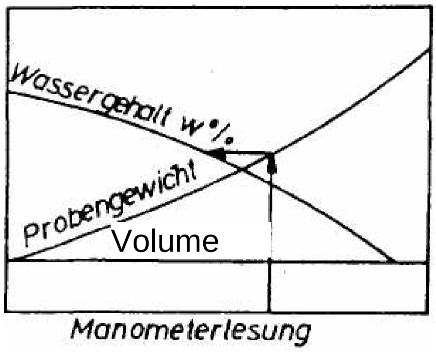

Fig. 2: Determining the water content w *[in %]*

Record sheet for determining the water content (example)

Air Pycnometer no.: ###
Job designation: initial calibration
Responsible for test: John Smith
Date: 06.09.20##

Sample number					
Mass of the dry soil sample and of the test pot [in g]	3327				
Mass of the test pot [in g]	1707				
Mass of the earth-moist sample [in g]	1620				
Pressure-gauge reading [in bar]	0.891*)				
Water content in accordance with nomographic chart no. 1 [in %]	10.3				

* As an example, the pressure-gauge reading was determined after calibration had been performed from nomographic chart no. 1 for an Air Pycnometer.

12.2 Determination of the grain density

To improve the accuracy of testing (see Section 6 here), you should add a certain amount of water to the dried soil sample (for example, 300 g = 300 cm³). See Fig. 3 for the following procedure:
Find the mean value of the pressure-gauge reading on the bottom horizontal scale, and then go vertically upward to the volume scale on the graph. Then go to the right, horizontally along the volume scale, by the amount of the volume of the added water. This provides the corrected volume. Next go vertically until your line intersects the plot of the weight of dried sample (dry mass). Then go horizontally to the left to the scale at the far left side of the graph, for the weight per unit volume (specific gravity).

ρ_s

Mass of the dry sample
Volume
Addition of water = subtraction
Pressure-gauge reading

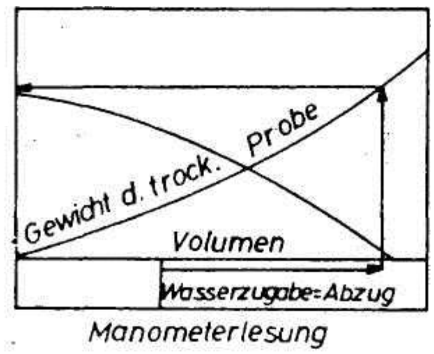

Fig. 3: Determining the weight per unit volume (specific gravity)

Determination of the grain density

Air Pycnometer no.: **###**
Job designation: **initial calibration**
Responsible for test: **John Smith**
Date: **06.09.20##**

Sample number					
Mass of the dry soil sample and test pot [in g]	3361				
Mass of the test pot [in g]	1707				
Dry mass of the soil sample *(m_t)* [in g]	1654				
First pressure-gauge reading [in bar]	0.769				
Volume in accordance with chart no. 1 [in cm³]. If less than 800 cm³, see point [1] below.	620				
Grain density [in g/cm³]	2.665				
More accurate volume determination by addition of water					
Addition of water [in g]	200				

2. Pressure-gauge reading [in bar]	1129*)				
Volume according to nomographic chart no. 1	822				
More accurate volume after subtraction of the additional water volume V'	622				
Specific gravity in accordance with nomographic chart no. 1	2.66				

* As an example, the pressure-gauge reading was determined after calibration had been performed from nomographic chart no. 1 for an Air Pycnometer.

12.3 Determination of various soil-mechanics parameters for soil samples taken from sampling cylinders in accordance with DIN 18125

12.3.1 Determination of the wet soil density

Analysis procedure:

Start by finding the volume (sampling cylinder plus soil sample) on the horizontal volume scale. Then go vertically upward to the wet mass. Now go horizontally to the left to the left side of the graph and read off the wet density ρ, which consists of soil, water, and air constituents (see Fig. 4 below).

Wet mass of the sample taken

ρ

Volume of sample taken

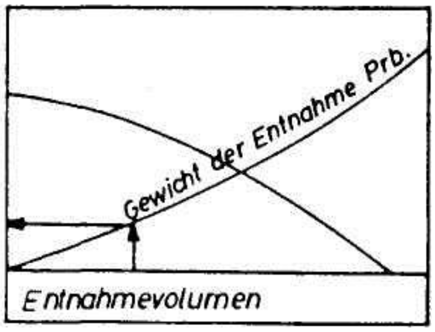

Fig. 4: Determination of wet density

12.3.2 Determination of the water content

Determine the water content as described under Section 12.1.
For further analysis, use the wet bulk density without air fraction (ρ) as a theoretical auxiliary value on the horizontal scale (intersection of sample mass and water content). Proceed the same on the left scale for dry density.

Sample mass (see 1)

ρ_d

ρ_n

See 3a
Volume containing air
Volume not containing air
Pressure-gauge reading

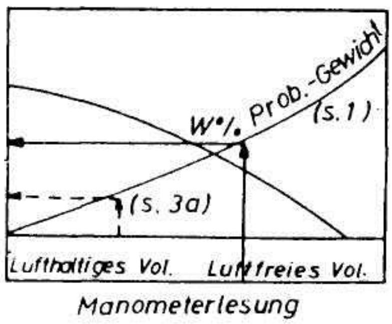

Fig. 5: Determination of the water content

12.3.3 Determination of the air content

The air content is read off as following, by using Fig. 6: Take a horizontal line from ρ_d to the point where it intersects the rising parabolic line from the initial point ρ_{in}: i.e., along the plot of the sample mass. From where the lines ρ_n and ρ_d intersect, go vertically up to the air-content scale, and read off the air content there.

Air content in volume % L %

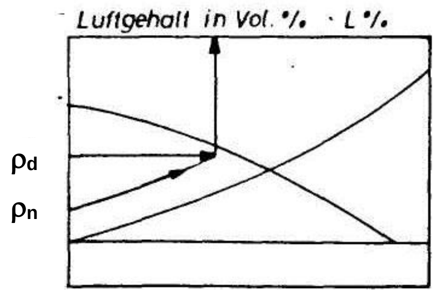

Fig. 6: Determination of the air content

12.3.4 Determination of the dry density

Determine the dry density (ρ_d) of the sample taken by the following procedure: Take a horizontal line from auxiliary value ρ_d through the water-content line to make an intersection on the right side of the dry-density scale at the value ρ_{dt}. Since this value does not include the air content, locate it on the density scale, and extend its horizontal line from there vertically, from the air content to the intersection.

1. From this intersection, the parabolic line leads downward to the left density scale to the left density scale. This intersection on the left density scale gives the required dry density ρ_d.

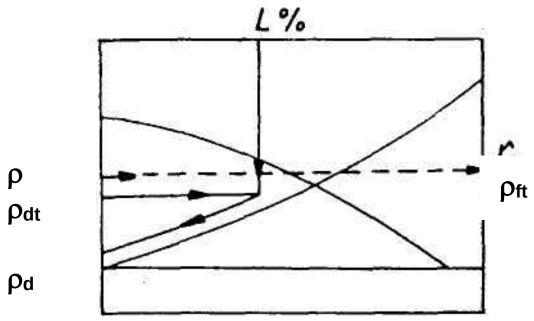

Fig. 7: Determination of the dry density

12.3.5 Determination of the pore volume

You can read off the pore volume at the right side of the graph, at the density scale, at the level of the ρ_d found here. In other words: the pore-volume scale (n) rises in scale values from the bottom to the top.

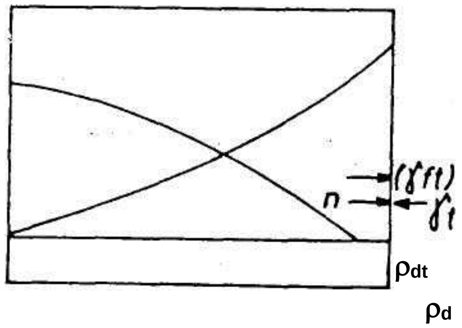

Fig. 8: Determination of the pore volume

13. Correction of a volume measurement

The best checking of a volume measurement takes place with the aid of a volume calibration set. If you do not have a volume calibration set, you can also check the volume measurement with an exactly weighed quantity of water, as follows:
Perform the measurement.
Empty the test pot and clean it.
Fill the test pot with water and determine the volume as described in Section 3.

Example 1:
Testing of a soil sample, with a mean pressure-gauge reading of 1.252 bar on chart no. 1, resulted in a volume of 824 ml (V_1). A verification measurement was then made to confirm this result, by weighting 824 g of water. The pressure-gauge reading then showed 1.257 bar, instead of 1.252 bar. This check means that the soil sample has a volume less than 824 ml.

Correction now takes place as follows: The reading of the measurement for the soil sample showed a value of 1.252 bar. According to chart no. 1, this results in a volume of 824 ml. The verification measurement showed a value of 1.257 bar. According to chart no. 1, this results in a volume of 826 ml. These results provide a correction of 0.005 bar, which means a volume of 2 ml. Subtract 2 ml from the volume determined in the first measurement. This now means that the actual volume of the soil test is 822 ml.

Example 2:
The verification measurement for the water filling resulted in a lower value: e.g., 1.247 bar instead of 1.252 bar in the test made on the soil sample. This means that the volume of the soil sample is larger than the volume of the water filled into the pot for checking and correction. Chart no. 1 shows that the volume difference between 1.252 bar and 1.247 bar is as follows: 824 ml minus 818 ml = 6 ml. This 6 ml is the correction amount that must be added: 824 ml plus 6 ml = 830 ml, which is the corrected and actual volume of the soil sample.

Checking the volume in an Air Pycnometer in case of incorrect reading of a precision pressure gauge, or in case of deviation from the calibration data:

Sample number:		1	1 *)
Dry mass plus the mass of the test pot [in g]:		3.892	3.892
Mass of the test pot [in g]		1.707	1.707
Dry mass of the soil sample m_d [in g]		2.185	2.185
Pressure-gauge reading [in bar]	Reading 1	1.251	1.251
	Reading 2	1.253	1.252
	Reading 3	1.252	1.253
Mean value [in bar]		1.252	1.252
(i) Volume from chart no. 1 [cm³]		824	824

Correction of the volume by using a water filling (i)

Water filling in the test pot (i) [in g]		824	824
Pressure-gauge reading for this water filling = Volume i	Reading 1	1.257	1,247
	Reading 2	1.258	1.246
	Reading 3	1.256	1.248
Mean value [in bar]		1.257	1.247
Volume ii from the chart [cm³]		826	818
Difference between volume i and volume ii = correction value for the correction to be applied to volume i [in cm³]		-2	+ 6
V = corrected volume [in cm³]		822	830
Grain density $\rho_s = \frac{m_d}{V}$ [g/cm³]		2.66	2.63

Note: The above numerical examples have been chosen to explain the correction of opposing correction values.

14. Influence of temperature on the measurement results

To ensure optimal measuring accuracy when using an Air Pycnometer, be sure that the following temperatures are as nearly the same as possible: the Air Pycnometer instrument itself, the soil sample to be tested, any water that is used, and the room temperature.
Experience has shown the following: if the soil-sample temperature is less than the air temperature, the resulting volume will be too small. This will in turn result in bulk density and grain density findings that are too great. The results for water content would then be too low.
On the other hand, if the soil sample has a temperature that is greater than room temperature, this would result in a volume measurement that is too great. This would mean, for a warm, moist soil sample, a water-content result that is too high.
These incorrect results can be prevented by allowing all items to have as nearly the same temperature as possible: the Air Pycnometer instrument itself, the soil sample to be tested, any water that is used, and the room temperature. If, for example, the soil sample is not the same temperature as the Air Pycnometer or the air in the room, temperature compensation can be provided by stirring or moving the soil sample. With a mass of the sample of 1,000 to 2,000 g, this stirring or moving can take about 10 minutes. When determining water content, temperature differences of up to 2° C are acceptable. In determining the grain density, however, it is absolutely necessary that the temperatures all be the same.

Contact for support:
Please get in touch will the following specialists for testing the function of the Air Pycnometer, calibrating the Air Pycnometer, preparation of the analysis charts, and new calibration of the Air Pycnometer after it has been repaired by TESTING

15. After-sales service and spare parts

A great deal of care has been taken to ensure that this Operational Manual is correct. We cannot, however, guarantee that it is without mistakes or errors, or that all information contained herein will continue to remain valid in the event of technical changes.

15.1 Date of issue of this Operational Manual

Edition no. 6
Date of issue: Jan of 2009

15.2 Copyright

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- Provided to any other persons.

Any person acting in violation of the above stipulations may be prosecuted before a court of law.

15.3 Contact for help and spare parts

If you have any technical questions, or if you require spare parts, please get directly in touch with the following address:

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Germany
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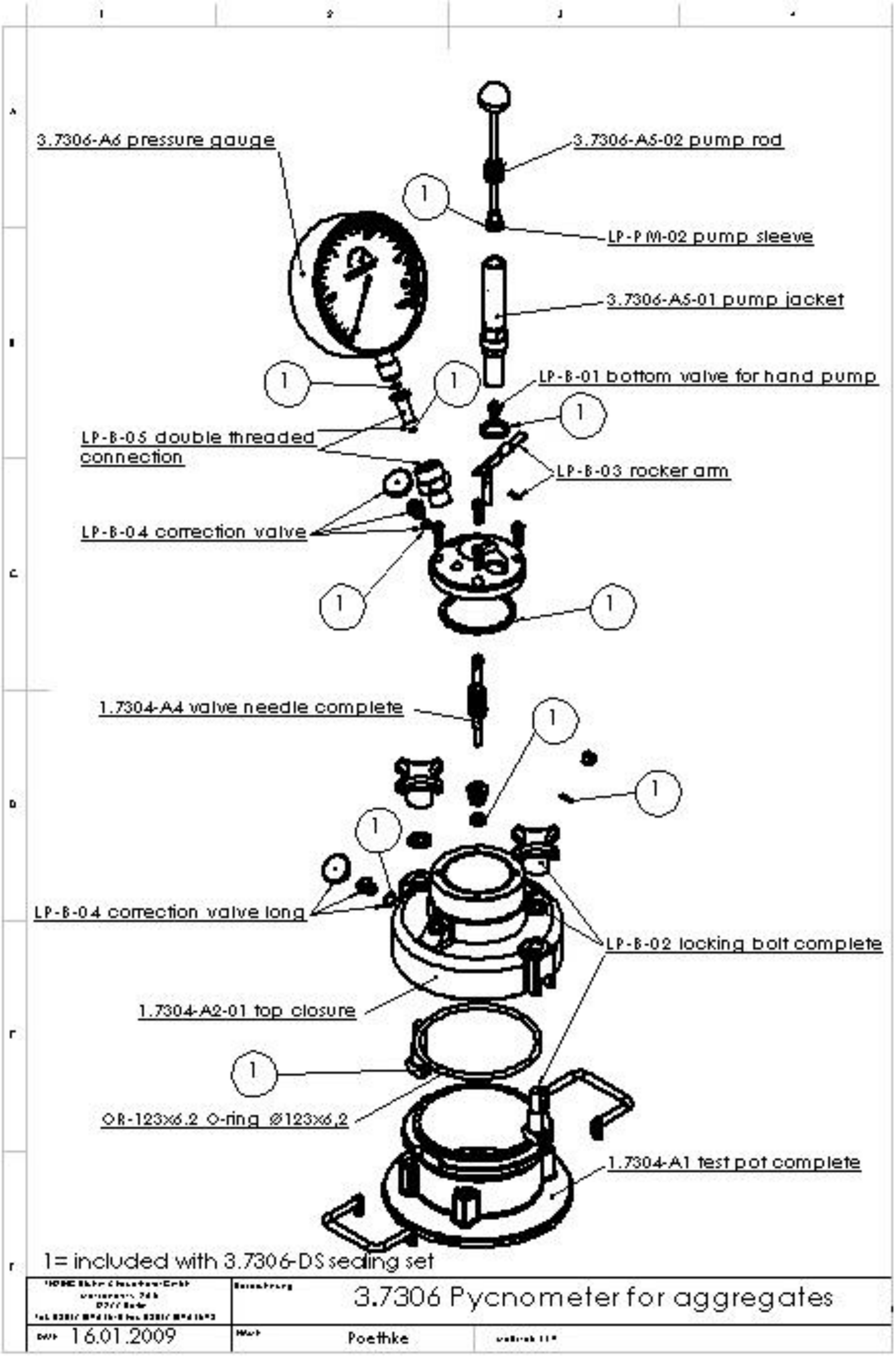
Fax: +49 / 30 / 710 96 45-98
E-mail: info@testing.de
www.testing.de

List of spare parts

For: Air Pycnometer, 1 Litre

Old part numbers	New part numbers	Qty	Name of parts	Including the following:
3.7306	3.7306	1	LP unit, complete	
	3.7306-O	1	Upper part, without test pot	
1.7304-01	1.7304-A1	1	Test pot, complete	
1.7304-02.01	1.7304-A2-01	1	Cover	O ring
N-LP-88	OR-123x6.2	1	O ring for cover	
2.7302-05	LP-B-02	2	Clamping bolts, complete	Star handle, U washer, and bolt
N-LP06	LP-B-03	1	Rocker arm, complete	Bolts, lock rings
1.7304-04	1.7304-A4	1	Valve needle, complete	O ring, bolt, springs, etc.
N-LP07	LP-B-04	1	Correction valve	
	LP-B-04.L		Correction valve, long	
N-LP08	LP-B-05	1	Double threaded connection, complete	O rings, pipe connections
3.7306-06	3.7306-A5	1	Pump, complete	
3.7306-07	3.7306-A5-01	1	Pump jacket, complete	
N-LP03	LP-B-01	1	Bottom valve, complete	
3.7306-11	3.7306-A5-02	1	Pump rod, complete	
3.7306-08.01	3.7306-A6	1	Pressure gauge	
	3.7306-DS	1	Sealing set	
1.7304-11.05	LP-PM-02	1	Pump sleeve	
	3.7306.01		Adjusting block, 600 cm^3	
	3.7306.02		Volume calibration set	


3.7306-A6 pressure gauge
3.7306-A5-02 pump rod
LP-PM-02 pump sleeve
3.7306-A5-01 pump jacket
LP-B-01 bottom valve for hand pump
LP-B-05 double threaded connection
LP-B-03 rocker arm
LP-B-04 correction valve
1.7304-A4 valve needle complete
LP-B-04 correction valve long
LP-B-02 locking bolt complete
1.7304-A2-01 top closure
OR-123x6.2 O-ring Ø123x6,2
1.7304-A1 test pot complete
1= included with 3.7306-DS sealing set
3.7306 Pycnometer for aggregates
16.01.2009
Poethke