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Anton Paar K. G.
A-8054 GRAZ, Postfach 58
Kärntner Strasse 322
Phone (0 31 6) 28 26 12-0
Teletex 33 16 246
Fax (0316) 28 50 69
AUSTRIA EUROPE

Instruments for
- density/concentration
- rheology
- X-ray structure analysis
- preparation for trace analysis
- preparation for electron microscopy
- ultra-microhardness
- fibre testing
- medical equipment
- astronomy ... and others

DMA 35



Anton Paar K.G.
A-8054 GRAZ AUSTRIA · EUROPE

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1. GENERAL INTRODUCTION

One of the most fundamental properties of liquids, solutions, or gases is their true density, that is, their mass per unit volume. Pressure and temperature represented by compressibility and cubic coefficient of expansion are important values which affect the volume. When measuring the density of a sample these values have to be considered by the use of tables and formulae, and often time-consuming work must be performed, the more careful, the better accuracy of measurement is required.

With the DMA 35 hand-held density meter you have purchased an instrument that does not require time-consuming and difficult manipulations of balances, lab vessels, or thermometers.

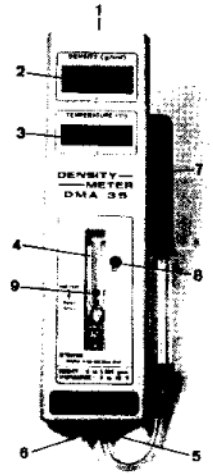
Within a few seconds the instrument provides high-accuracy results which in no way are manipulatable or depend on measurement conditions.

The sample to be measured is specified on its total property. This is valid also for the gaseous content or solid particles contained in liquids. The temperature is the other value that is determined exactly in order to be able to indicate the density of the sample at the measuring temperature.

Being powered by a battery means that the DMA 35 can conveniently be used for precise density measurement in the field.

To enjoy all these virtues for a long time, it is only necessary to take care in cleaning the instrument and to replace the battery from time to time.

2. DESCRIPTION OF THE INSTRUMENT



1. ON/OFF switch
2. Density (or density-related value) display
3. Temperature display
4. Oscillator (measuring cell)
5. Filling nozzle with syringe fitting
6. Suction nozzle
7. Rubber bulb
8. Calibration potentiometer
9. Battery check

The DMA 35 density meter incorporates a hand-held and battery-powered instrument based upon the mechanical oscillator technique.

Three versions are available for the determination of

a) true density ρ $\left[\text{g cm}^{-3}\right]$ (instrument reads true density of the sample at the measured temperature)

b) relative density d_{3}^{3} [-] (instrument shows density of the sample at the measuring temperature divided by the density of water at the same temperature or by a constant temperature of 4 °C resp. 20 °C)

c) concentration of solutions c (DMA 35 indicates percentage of weight of the sample in a 100 g solution).

Principle of measurement

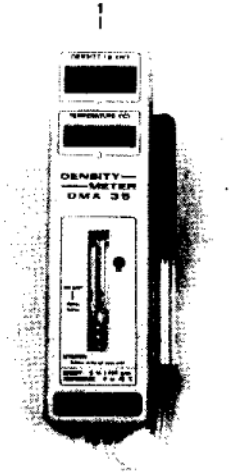
The sample to be measured is introduced into a hollow U-shaped oscillator [4] made of borosilicate glass DURAN 50. This sample tube is electromagnetically excited to perform undamped oscillations.
Since the volume of sample participating in the vibration is kept constant by the construction of the oscillator, the period depends only on the sample's density and the temperature of the sample tube.
In order to eliminate the temperature coefficient of the oscillator the temperature of the oscillator is determined.
From the period a built-in digital processor calculates according to the equation

$$\rho = A\,(T^2 - T_o^2)$$

the true density of the sample, where:

T is the actual period, T_o the period of the empty oscillator forming one calibration constant and A the second, for the individual oscillator. A and T_o are determined at manufacture and are stored in the processor's non-volatile memory. When measuring relative density or concentration A and T_o are modified accordingly.

3. COMMENCEMENT OF OPERATION

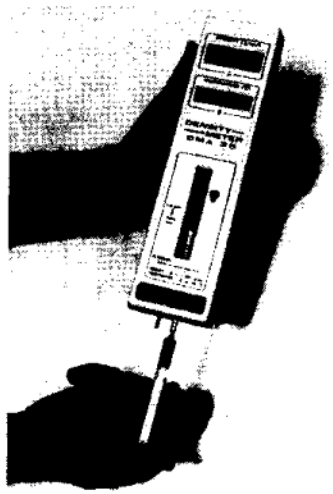


Switch [1] in position ON.
After switching on, the instrument segment test of the display is performed automatically for about two seconds. The sample can then be introduced into the oscillator.

4. THE ACTUAL MEASUREMENT

Filling the sample tube

a) By means of a hypodermic syringe:

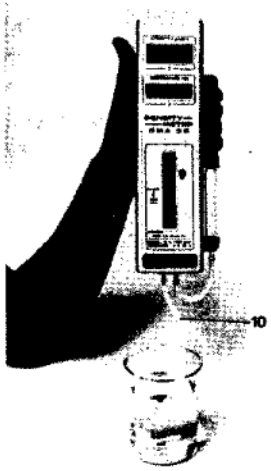


The right hand nozzle fits the Record cone of hypodermic syringes. A minimum amount of sample of approx. 2 cm^3 is required. This mode of filling should be used when measuring viscous samples.
Ensure that there are no air bubbles in the measuring cell.
If the density display shows only eights, the oscillator is not properly filled and the filling procedure must be repeated.

A T T E N T I O N :

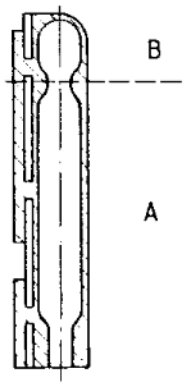
Do not apply a pressure exceeding 0.5 bar. It may cause leakage inside the instrument.

b) By means of the attached suction unit
(when ordering Cat.No. 5035x.1 only):



The suction unit consists of a Silicone rubber bulb, a glass vessel, as well as the corresponding suction tubes. The unit is fitted to the right hand side of the DMA 35 in such a way that it can be operated with the left hand leaving the right hand free for other work. Suction tubes made of either Silicone rubber or Viton are available and must be chosen according to the sample's properties.
Instead of the suction hose [10] a PTFE tube can also be used.

The Silicone rubber bulb has two sections. When filling the oscillator, squeeze the lower part [A], dip the suction tube [10] (which should not exceed a length of 30 cm) into the sample and release the bulb. This causes the sample to be sucked through the oscillator into the glass vessel. Make sure that no air bubbles enter the oscillator. In order to get air bubbles out of the measuring cell push the sample back by pressing the upper part of the rubber bulb [B] with the forefinger or start a new filling procedure.



Take care that samples dissolving Silicone rubber do not contact the rubber bulb.

Temperature equilibrium

High differences in temperature between oscillator and sample lead to erroneous results. If this difference is lower than 5 K temperature equilibrium is carried out during filling procedure. For higher differences one has to wait correspondingly longer. The density reading will only be valid when the temperature indicated for the oscillator filled with the sample does not deviate by more than ±5 K from the temperature initially displayed for the empty oscillator (which is, under steady conditions, equal to the ambient temperature).

For example: Ambient (initial) temperature 25 °C as shown at the temperature display on the instrument before filling. Sample temperature before filling is 40 °C. Immediately after filling the temperature reading will rise up to approx. 38 °C. Now one has to wait for temperature equilibrium. The density reading can be taken as valid after passing the 30 °C (25 + 5) limit.

Reading and evaluation of the measured values

a) Density measurement
After temperature equilibrium (waiting time depends on the temperature of the sample) the density and temperature values can be read. The density value indicated on the display corresponds to the true density at the measured temperature. Ambient temperature can vary between 0 and 40 °C. Liquids with a density of up to 1.999 g cm^{-3} can be measured. The accuracy is $\pm 1 \times 10^{-3}$ g cm^{-3}.

b) Relative density
When temperature equilibrium has been reached both relative density and temperature can be read. The instrument shows density of the sample at the measuring temperature divided by the density of water at the same temperature or by a constant temperature. Ambient temperature can range between 10 and 30 °C. Relative densities up to 1.999 can be measured with an accuracy of $\pm 1 \times 10^{-3}$. The measured value is a non-dimensional quantity.

c) Concentration
After temperature equilibrium has been reached the concentration of a sugar solution can be read; that means percentage of sugar by weight in a 100 g solution. Ambient temperature range is from 15 to 25 °C. Measuring range is 10 °Brix. Different versions of 0.....50 °Brix are available. Accuracy is ±0.1 °Brix.

NOTE: The DMA 35 instrument is calibrated for one field of application (either true density, relative density, or concentration) only. For this reason, one DMA 35 can determine only one of the measuring values mentioned above.

REMARK: For high differences between ambient and sample temperature, the oscillator can become clouded outside when measuring cold liquids. In order to avoid erroneous results, the sample to be measured should have the temperature of the oscillator approximately before filling.

5. MAINTENANCE

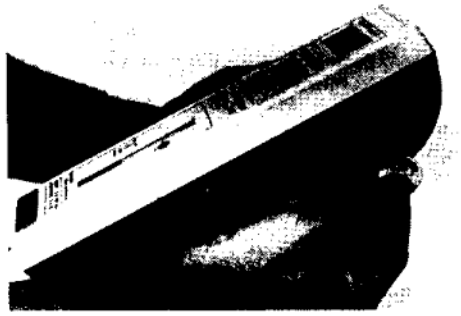
Except for periodic cleaning of oscillator and exchange of battery the instrument operates maintenance-free.
The housing is made of Pocan which is resistant to most chemicals (except chloroform, glacial acetic acid, concentrated hydrochloric acid, concentrated nitric acid).
As the housing is not completely waterproof it may be necessary to slip over a protecting cover (Cat.No. 50350.9.3) when operating the instrument under extreme ambient conditons.

Cleaning the oscillator

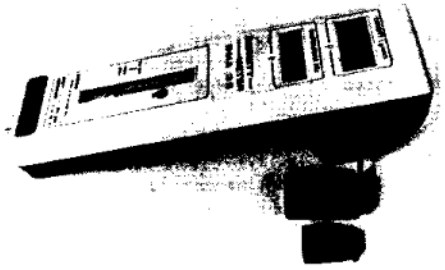
Cleaning is performed by repeated rinsing with a solvent. The same is valid for the glass vessel of the suction unit.
In addition, cleaning should be carried out when the instrument is not operated for longer time intervals and, on the other hand, when samples of different properties are measured.

Exchange of battery

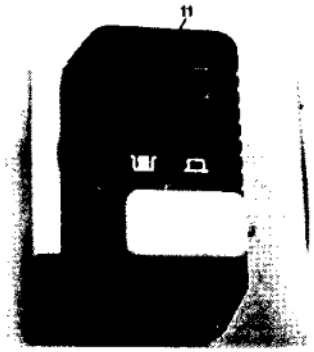
A voltage monitor will show a low battery (red LED [9]) and protect the display units in case of too low a supply voltage. Replace the old battery by a new one or, if an accumulator is used, this has to be charged.
Charging time is approx. 14 hours. Since a new accumulator is usually uncharged it should be charged before commencement of operation.



The battery cover can be loosened by a coin and removed.



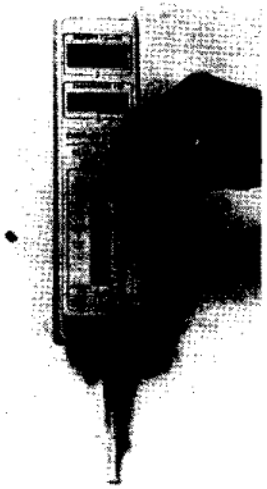
Take out battery after removing contact clip.



For charging put the accumulator into a plug charger [11] (consider polarity!) and then fit the plug charger into a power socket. Correct charging is indicated by the charging control.

Calibration

If the value of a sample of known density, relative density, or concentration (e.g. H_2O) indicated deviates from table values, the difference can be corrected by adjusting the calibration potentiometer.
Sedimentation within the oscillator or aging could be the reasons for such an effect.



Calibration with attached screw-driver

For calibration introduce a sample of known density into the sample tube and compare the result with the table value.
If the DMA 35 was calibrated on relative density d_3^3, the display must show for H_2O always 1.000.
If the DMA 35 is calibrated on relative density d_4^{20} or d_{20}^{20}, the density of the medium to be measured at 20 °C divided by the density of H_2O at 4 °C resp. at 20 °C is displayed.

$$d_4^{20} = \frac{\rho_{\text{medium } 20\ ^\circ C}}{\rho_{H_2O \quad 4\ ^\circ C}} \quad ; \quad d_{20}^{20} = \frac{\rho_{\text{medium } 20\ ^\circ C}}{\rho_{H_2O \quad 20\ ^\circ C}}$$

Density table for H_2O see appendix.

6. MALFUNCTIONS AND THEIR REASONS

a) Density display shows nothing but eights, temperature is indicated correctly.
Oscillator contains air bubbles - new filling necessary.
Oscillator is broken - contact your service department.

b) Wrong density is indicated
Sedimentations within the oscillator. - Careful cleaning with solvents required (alcohol, etc.), see item 5, page 6.
If necessary, recalibrate as described under item 5, page 7.
If a wrong density value is still indicated, please, contact your service department.

c) Both the density- and temperature display remain blank, low battery indicator lights up.
Discharged battery - replace it by a new one (or charge accumulator).

d) Both the density- and temperature display remain blank,
low battery indicator does not light up.
Test battery and replace it if necessary.
If displays are still blank, please, contact your service department.

Remark: Service by the user invalidates warranty.
Since oscillator and glass tube can only be destroyed by faulty handling (dropping, etc.) no warranty is given for glass parts.

7. APPENDIX

Accessories



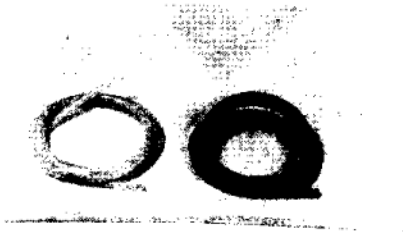
Carrying case with all standard accessories
(Cat. No. 54441) consisting of:

1 carrying case
10 syringes with Record fitting
1 m Silicone hose 2x4
1 m Viton hose 2x4
0.5 m Silicone hose 3x5
0.5 m Viton hose 3x5
1 pile socket
1 screw driver

Standard accessories (Cat.No. 50350.9.1)
(as above, however, without carrying case and screw driver)

Hoses

1 m Silicone hose 2x4	(Cat. No. 51273)
1 m Silicone hose 3x5	(Cat. No. 50814)
1 m Viton hose 2x4	(Cat. No. 54628)
1 m Viton hose 3x5	(Cat. No. 54629)
0.25 m PTFE suction tubes	(Cat. No. 55340)



9 V Alcaline Battery 6LF 22

(Cat. No. 53594)



9 V Accumulator

(Cat. No. 54444)



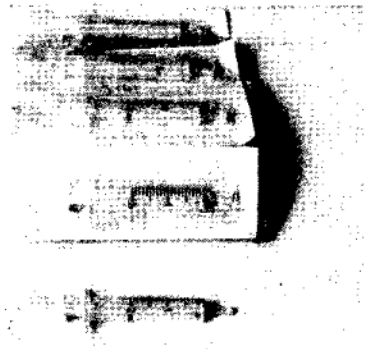
Accumulator charger with Europe plug

(Cat. No. 54445)



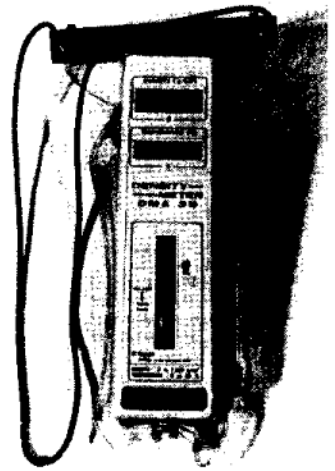
10 syringes with Record fitting

(Cat. No. 54732)



PVC protecting cover

(Cat. No. 55339)



DENSITY OF WATER

Dichte von luftfreiem Wasser in kg/m³ in Abhängigkeit von der Celsius-Temperatur in der Internationalen Praktischen Temperaturskala von 1968

t_{68} °C	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	$\Delta\varrho/\Delta t$ kg/m³ / 0,1 °C	$\Delta\varrho$ luft-gesättigt – luftfrei kg/m³
0	999,8396	999,8463	999,8528	999,8591	999,8653	999,8713	999,8771	999,8827	999,8882	999,8934	0,0059	−0,0026
1	999,8985	999,9035	999,9082	999,9128	999,9172	999,9214	999,9254	999,9293	999,9330	999,9365	0,0041	−0,0027
2	999,9399	999,9431	999,9461	999,9489	999,9516	999,9541	999,9565	999,9587	999,9607	999,9625	0,0024	−0,0028
3	999,9642	999,9657	999,9670	999,9682	999,9692	999,9701	999,9708	999,9713	999,9717	999,9719	0,0008	−0,0030
4	999,9720	999,9718	999,9716	999,9711	999,9705	999,9698	999,9689	999,9678	999,9666	999,9652	−0,0008	−0,0031
5	999,9637	999,9620	999,9602	999,9582	999,9560	999,9537	999,9513	999,9487	999,9459	999,9430	−0,0024	−0,0033
6	999,9399	999,9367	999,9334	999,9299	999,9262	999,9224	999,9184	999,9143	999,9101	999,9057	−0,0039	−0,0034
7	999,9011	999,8964	999,8916	999,8866	999,8815	999,8762	999,8708	999,8652	999,8595	999,8537	−0,0053	−0,0035
8	999,8477	999,8416	999,8353	999,8289	999,8223	999,8157	999,8088	999,8019	999,7947	999,7875	−0,0068	−0,0035
9	999,7801	999,7726	999,7649	999,7571	999,7492	999,7411	999,7329	999,7246	999,7161	999,7075	−0,0081	−0,0034
10	999,6987	999,6898	999,6808	999,6717	999,6624	999,6530	999,6434	999,6337	999,6239	999,6140	−0,0095	−0,0033
11	999,6039	999,5937	999,5834	999,5729	999,5623	999,5516	999,5408	999,5298	999,5187	999,5074	−0,0108	−0,0031
12	999,4961	999,4846	999,4730	999,4612	999,4494	999,4374	999,4253	999,4130	999,4007	999,3882	−0,0121	−0,0029
13	999,3756	999,3628	999,3500	999,3370	999,3239	999,3106	999,2973	999,2838	999,2702	999,2565	−0,0133	−0,0026
14	999,2427	999,2287	999,2146	999,2004	999,1861	999,1717	999,1571	999,1424	999,1276	999,1127	−0,0145	−0,0023
15	999,0977	999,0826	999,0673	999,0519	999,0364	999,0208	999,0051	998,9892	998,9733	998,9572	−0,0157	−0,0020
16	998,9410	998,9247	998,9083	998,8917	998,8751	998,8583	998,8414	998,8244	998,8073	998,7901	−0,0168	−0,0017
17	998,7728	998,7553	998,7378	998,7201	998,7023	998,6845	998,6665	998,6483	998,6301	998,6118	−0,0179	−0,0014
18	998,5934	998,5748	998,5562	998,5374	998,5185	998,4995	998,4804	998,4612	998,4419	998,4225	−0,0190	−0,0011
19	998,4030	998,3833	998,3636	998,3438	998,3238	998,3037	998,2836	998,2633	998,2429	998,2224	−0,0201	−0,0009
20	998,2019	998,1812	998,1604	998,1395	998,1185	998,0973	998,0761	998,0548	998,0334	998,0119	−0,0212	−0,0006
21	997,9902	997,9685	997,9467	997,9247	997,9027	997,8805	997,8583	997,8360	997,8135	997,7910	−0,0222	−0,0004
22	997,7683	997,7456	997,7227	997,6998	997,6767	997,6536	997,6303	997,6070	997,5835	997,5600	−0,0232	−0,0002
23	997,5363	997,5126	997,4887	997,4648	997,4408	997,4166	997,3924	997,3680	997,3436	997,3191	−0,0242	−0,0001
24	997,2944	997,2697	997,2449	997,2200	997,1950	997,1699	997,1446	997,1193	997,0939	997,0685	−0,0252	0,0000
25	997,0429	997,0172	996,9914	996,9655	996,9396	996,9135	996,8873	996,8611	996,8347	996,8083	−0,0261	0,0000
26	996,7818	996,7551	996,7284	996,7016	996,6747	996,6477	996,6206	996,5934	996,5661	996,5388	−0,0270	0,0000
27	996,5113	996,4837	996,4561	996,4284	996,4005	996,3726	996,3446	996,3165	996,2883	996,2600	−0,0280	0,0000
28	996,2316	996,2032	996,1746	996,1460	996,1172	996,0884	996,0595	996,0305	996,0014	995,9722	−0,0289	0,0000
29	995,9430	995,9136	995,8842	995,8546	995,8250	995,7953	995,7655	995,7356	995,7056	995,6756	−0,0298	0,0000
30	995,6454	995,6152	995,5848	995,5544	995,5239	995,4934	995,4627	995,4319	995,4011	995,3701	−0,0306	0,0000
31	995,3391	995,3080	995,2768	995,2456	995,2142	995,1828	995,1512	995,1196	995,0879	995,0561	−0,0315	0,0000
32	995,0243	994,9923	994,9603	994,9282	994,8960	994,8637	994,8313	994,7988	994,7663	994,7337	−0,0323	0,0000
33	994,7010	994,6682	994,6353	994,6024	994,5693	994,5362	994,5030	994,4697	994,4364	994,4029	−0,0332	0,0000
34	994,3694	994,3358	994,3021	994,2683	994,2345	994,2005	994,1665	994,1324	994,0982	994,0640	−0,0340	0,0000
35	994,0296	993,9952	993,9607	993,9261	993,8915	993,8567	993,8219	993,7870	993,7521	993,7170	−0,0348	0,0000
36	993,6819	993,6467	993,6114	993,5760	993,5406	993,5050	993,4694	993,4338	993,3980	993,3622	−0,0356	0,0000
37	993,3263	993,2903	993,2542	993,2181	993,1818	993,1455	993,1092	993,0727	993,0362	992,9996	−0,0363	0,0000
38	992,9629	992,9261	992,8893	992,8524	992,8154	992,7784	992,7412	992,7040	992,6668	992,6294	−0,0371	0,0000
39	992,5920	992,5545	992,5169	992,4792	992,4415	992,4037	992,3658	992,3279	992,2899	992,2518	−0,0378	0,0000
40	992,2136											

Aus H. WAGENBRETH und W. BLANKE: „Die Dichte des Wassers im Internationalen Einheitensystem und in der Internationalen Praktischen Temperaturskala von 1968" PTB — Mitteilungen 6/71, 412.

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