International Standard 5281

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Aromatic hydrocarbons — Benzene, xylene and toluene — Determination of density at 20 °C

Hydrocarbures aromatiques — Benzène, xylène et toluène — Détermination de la masse volumique à 20 °C

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5281 was developed by Technical Committee ISO/TC 78, *Aromatic hydrocarbons*, and was circulated to the member bodies in October 1977.

It has been approved by the member bodies of the following countries :

Australia	Germany, F.R.	Portugal
Austria	Hungary	Romania
Brazil	India	South Africa, Rep. of
Bulgaria	Korea, Rep. of	Turkey
Chile	Mexico	United Kingdom
Czechoslovakia	Netherlands	USSR
Egypt. Arab Rep. of	Philippines	Yugoslavia
France	Poland	

No member body expressed disapproval of the document.

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Aromatic hydrocarbons — Benzene, xylene and toluene — Determination of density at 20 °C

WARNING — Aromatic hydrocarbons are generally toxic by inhalation, ingestion or skin absorption. Volatile aromatic hydrocarbons are also highly flammable.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies pyknometer and hydrometer methods for the determination of the density at 20 °C of benzene, xylene and toluene.

2 REFERENCES

ISO 387, *Hydrometers — Principles of construction and adjustment.*

ISO 649, *Laboratory glassware — Density hydrometers for general purposes.*[1]

ISO 1995, *Aromatic hydrocarbons — Sampling.*[2]

ISO 3507, *Pyknometers.*

3 DEFINITION

For the purpose of this International Standard, the following definition applies :

density : The ratio of mass to volume at a given temperature called the reference temperature.

For the purposes of standard tests, density is expressed in grams per millilitre. For all products the reference temperature is 20 °C.

This definition is concerned with mass, not with weight, in air, but the conversion tables given in the pyknometer method make allowance for the weighing in air. The scales of density hydrometers complying with ISO 649 are graduated in terms of mass per unit volume.

4 PRINCIPLES

4.1 Pyknometer method

Weighing of a pyknometer empty, then filled with water and, finally, filled with the aromatic hydrocarbon under test, at known temperatures. Calculation of the density from the values obtained, applying certain corrections given in tables.

4.2 Hydrometer method

Immersion of a hydrometer in the aromatic hydrocarbon under test, and recording of the hydrometer scale reading and the temperature. Calculation of the density from the values obtained, after applying a correction, obtained from the calibration certificate.

5 SAMPLING

Take a representative sample of not less than 1 000 ml from the bulk of the material.

Recommended methods of sampling are given in ISO 1995.

6 PYKNOMETER METHOD

6.1 Apparatus

6.1.1 Pyknometer, Lipkin, of borosilicate glass, 10 ml capacity, complying with the requirements of ISO 3507, type 1.

6.1.2 Water bath, glass-sided, of depth greater than 300 mm, thermostatically controlled to within 0,1 °C at any convenient temperature between 10 and 30 °C.

6.1.3 Thermometers, complying with the requirements given in the annex.

6.2 Procedure

6.2.1 *Cleaning*

Before calibrating the pyknometer (6.1.1), or when any liquid fails to drain cleanly from the walls or capillary of the pyknometer, clean it as follows.

Fill the pyknometer with chromic acid solution, or alternatively with a suitable distilled detergent. Allow to stand overnight empty and rinse well with distilled water followed by anhydrous acetone. Dry the pyknometer by passing a slow stream of dry filtered air through it. Between determinations, rinse the pyknometer with toluene followed by anhydrous acetone and dry it as before.

1) At present at the stage of draft. (Revision of ISO/R 649.)

2) At present at the stage of draft.

6.2.2 *General procedure*

Remove any static charge from the dry, clean pyknometer, which may conveniently be done by breathing on it, or alternatively by wiping it with a clean, lint-free cloth slightly dampened with water.

Suspend the pyknometer in the balance case for 15 min, then weigh it to the nearest 0,1 mg.

Fill the pyknometer by holding it in an upright position and placing the hooked tip in the liquid; the liquid will be drawn over the bend in the capillary tube by surface tension and the pyknometer will then fill by syphoning. Break the syphon when the liquid level in the bulb arm of the pyknometer reaches the graduated capillary tube. Clean the hooked tip, remove any static charge and weigh as described above. Calculate the mass of liquid in the pyknometer. Place the filled pyknometer in the holder and place the assembly in the water bath (6.1.2) so that the pyknometer is vertical and the liquid levels in the capillary arms are just below the surface of the water. When the liquid has reached the water bath temperature as indicated by a static liquid level (usually in about 10 min) and while the instrument is still in the water bath, read the liquid levels in the capillary arms to the nearest 0,2 of a small division.

Record the sum of the two readings to give the scale volume and also record the temperature of the water bath to the nearest 0,1 °C.

6.2.3 *Calibration*

Using freshly boiled and cooled distilled water, and following the procedure described above, record the mass of water, the scale volume and the temperature reading for a filling that gives a water level in the pyknometer that is near the top of each scale. Repeat this operation three times, removing a little water each time, so that the series of scale volumes obtained is spaced at approximately equal distances over the whole length of the pyknometer scale.

For each series of recordings calculate the volume, V_{20}, in millilitres, of the pyknometer at 20 °C as follows :

$$V_{20} = m_t \times M_1$$

where

m_t is the difference, in grams, between the results of weighing the pyknometer full and weighing it empty at t °C;

M_1 is the multiplication factor, in millilitres per gram, obtained from table 1 as a function of t;

t is the water bath temperature, in degrees Celsius.

Plot the corresponding scale volumes and the volumes at 20 °C and construct a mean straight line through the four points, none of which should be more than half a pyknometer scale division from this line. If this limitation is not satisfied and, after making further checks, it is found that an acceptable straight line cannot be constructed through the points, a non-uniform bore of the capillary tubes is indicated and the pyknometer shall be rejected.

The line so obtained is the calibration graph of the pyknometer relating the scale volume to the volume of the pyknometer at 20 °C.

6.3 Determination of density of aromatic hydrocarbons

Determine the density of the sample (see clause 5) using the procedure specified in 6.2.2.

6.4 Calculation of density

Calculate the density, ρ_{20}, in grams per millilitre, of the sample at 20 °C as follows :

$$\rho_{20} = \frac{m}{V_{20}} \times M_2 + 0{,}001\ 2$$

where

m is the corrected mass, in grams, of the test portion at t °C, obtained from the mass, the scale volume and the calibration graph;

M_2 is the multiplication factor, obtained from table 2 as a function of t;

t is the water bath temperature, in degrees Celsius;

V_{20} is the pyknometer volume at 20 °C, in millilitres, calculated in accordance with 6.2.3.

6.5 Precision

The precision of the test method, as obtained by statistical examination of interlaboratory results obtained for benzene, toluene and xylene, is as follows :

6.5.1 *Repeatability (r)*

The value below which the absolute difference between two single test results, on identical test material, obtained by one operator in one laboratory using the same equipment within a short interval of time, applying the standardized test method, may be expected to lie with a 95 % probability, is 0,000 2 g/ml.

6.5.2 *Reproducibility (R)*

The value below which the absolute difference between two single test results, on identical test material, obtained by operators in different laboratories, applying the standardized test method, may be expected to lie with a 95 % probability, is 0,000 3 g/ml.

TABLE 1 – **Multiplication factors M_1 for conversion of mass of water at t °C to volume of vessel at 20 °C**

t °C	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
10	1,001 45	1,001 46	1,001 47	1,001 49	1,001 49	1,001 50	1,001 50	1,001 51	1,001 52	1,001 53
11	1,001 54	1,001 55	1,001 56	1,001 57	1,001 58	1,001 59	1,001 60	1,001 61	1,001 62	1,001 63
12	1,001 64	1,001 65	1,001 66	1,001 67	1,001 68	1,001 69	1,001 70	1,001 71	1,001 72	1,001 74
13	1,001 75	1,001 76	1,001 77	1,001 78	1,001 80	1,001 81	1,001 82	1,001 83	1,001 85	1,001 86
14	1,001 87	1,001 88	1,001 90	1,001 91	1,001 92	1,001 94	1,001 95	1,001 97	1,001 98	1,001 99
15	1,002 01	1,002 02	1,002 04	1,002 05	1,002 06	1,002 08	1,002 09	1,002 11	1,002 12	1,002 14
16	1,002 15	1,002 17	1,002 18	1,002 20	1,002 22	1,002 23	1,002 25	1,002 26	1,002 28	1,002 30
17	1,002 31	1,002 33	1,002 35	1,002 36	1,002 38	1,002 40	1,002 41	1,002 43	1,002 45	1,002 46
18	1,002 48	1,002 50	1,002 52	1,002 54	1,002 55	1,002 57	1,002 59	1,002 61	1,002 63	1,002 65
19	1,002 66	1,002 68	1,002 70	1,002 72	1,002 74	1,002 76	1,002 78	1,002 80	1,002 82	1,002 84
20	1,002 86	1,002 88	1,002 90	1,002 92	1,002 94	1,002 96	1,002 98	1,002 00	1,003 02	1,003 04
21	1,003 06	1,003 08	1,003 10	1,003 12	1,003 14	1,003 16	1,003 18	1,003 21	1,003 23	1,003 25
22	1,003 27	1,003 29	1,003 32	1,003 34	1,003 36	1,003 38	1,003 40	1,003 43	1,003 45	1,003 47
23	1,003 49	1,003 52	1,003 54	1,003 56	1,003 59	1,003 61	1,003 63	1,003 66	1,003 68	1,003 70
24	1,003 73	1,003 75	1,003 78	1,003 80	1,003 82	1,003 85	1,003 87	1,003 90	1,003 92	1,003 95
25	1,003 97	1,004 00	1,004 02	1,004 05	1,004 07	1,004 10	1,004 12	1,004 15	1,004 17	1,004 46
26	1,004 22	1,004 25	1,004 27	1,004 30	1,004 33	1,004 35	1,004 38	1,004 41	1,004 43	1,004 46
27	1,004 49	1,004 51	1,004 54	1,004 57	1,004 59	1,004 62	1,004 63	1,004 67	1,004 70	1,004 73
28	1,004 76	1,004 79	1,004 81	1,004 84	1,004 87	1,004 90	1,004 93	1,004 95	1,004 98	1,004 01
29	1,005 04	1,005 07	1,005 10	1,005 13	1,005 15	1,005 18	1,005 21	1,005 24	1,005 27	1,005 30

TABLE 2 — **Multiplication factors M_2 for conversion of mass/volume ratio at t °C to uncorrected density at 20 °C**

t °C	Benzene	Toluene	Xylene
10,0	0,988 22	0,988 42	0,990 28
10,2	0,988 45	0,989 62	0,990 47
10,4	0,988 68	0,989 83	0,990 66
10,6	0,988 91	0,990 04	0,990 85
10,8	0,989 14	0,990 24	0,991 04
11,0	0,989 37	0,990 45	0,991 23
11,2	0,989 60	0,990 66	0,991 42
11,4	0,989 82	0,990 86	0,991 61
11,6	0,990 05	0,991 07	0,991 79
11,8	0,990 28	0,991 28	0,991 98
12,0	0,990 51	0,991 48	0,992 17
12,2	0,990 74	0,991 69	0,992 36
12,4	0,990 97	0,991 90	0,992 55
12,6	0,991 20	0,992 11	0,992 74
12,8	0,991 43	0,992 31	0,992 93
13,0	0,991 67	0,992 52	0,993 12
13,2	0,991 90	0,992 73	0,993 31
13,4	0,992 13	0,992 94	0,993 50
13,6	0,992 36	0,993 15	0,993 69
13,8	0,992 59	0,993 35	0,993 89
14,0	0,993 82	0,993 56	0,994 04
14,2	0,993 05	0,993 77	0,994 27
14,4	0,993 28	0,993 98	0,994 46
14,6	0,993 52	0,994 19	0,994 65
14,8	0,993 75	0,994 40	0,994 84
15,0	0,993 98	0,994 61	0,995 03
15,2	0,994 21	0,994 81	0,995 22
15,4	0,994 45	0,995 02	0,995 41
15,6	0,994 68	0,995 23	0,995 61
15,8	0,994 91	0,995 44	0,995 80
16,0	0,995 15	0,995 65	0,995 99
16,2	0,995 38	0,995 86	0,996 18
16,4	0,995 61	0,996 07	0,996 37
16,6	0,995 85	0,996 28	0,996 57
16,8	0,996 08	0,996 49	0,996 76
17,0	0,996 32	0,996 70	0,996 95
17,2	0,996 55	0,996 91	0,997 14
17,4	0,996 79	0,997 12	0,997 33
17,6	0,997 02	0,997 33	0,997 53
17,8	0,997 25	0,997 54	0,997 72

TABLE 2 (*continued*)

t °C	Benzene	Toluene	Xylene
18,0	0,997 49	0,997 75	0,997 91
18,2	0,997 72	0,997 96	0,998 11
18,4	0,997 96	0,998 17	0,998 30
18,6	0,998 20	0,998 38	0,998 49
18,8	0,998 43	0,998 59	0,998 69
19,0	0,998 67	0,998 80	0,998 88
19,2	0,998 90	0,999 01	0,999 07
19,4	0,999 14	0,999 22	0,999 27
19,6	0,999 38	0,999 43	0,999 46
19,8	0,999 61	0,999 64	0,999 66
20,0	0,999 85	0,999 85	0,999 85
20,2	1,000 09	1,000 06	1,000 04
20,4	1,000 32	1,000 27	1,000 24
20,6	1,000 56	1,000 48	1,000 43
20,8	1,000 80	1,000 69	1,000 63
21,0	1,001 04	1,000 91	1,000 82
21,2	1,001 27	1,001 12	1,001 02
21,4	1,001 51	1,001 33	1,001 21
21,6	1,001 75	1,001 54	1,001 41
21,8	1,001 99	1,001 75	1,001 60
22,0	1,002 23	1,001 96	1,001 80
22,2	1,002 47	1,002 18	1,001 99
22,4	1,002 71	1,002 39	1,002 19
22,6	1,002 94	1,002 60	1,002 38
22,8	1,003 18	1,002 81	1,002 58
23,0	1,003 42	1,003 02	1,002 78
23,2	1,003 66	1,003 24	1,002 97
23,4	1,003 90	1,003 45	1,003 17
23,6	1,004 14	1,003 66	1,003 36
23,8	1,004 38	1,003 87	1,003 56
24,0	1,004 62	1,004 09	1,003 76
24,2	1,004 86	1,004 30	1,003 95
24,4	1,005 11	1,004 51	1,004 15
24,6	1,005 35	1,004 72	1,004 35
24,8	1,005 59	1,004 94	1,004 54
25,0	1,005 83	1,005 15	1,004 74
25,2	1,006 07	1,005 36	1,004 94
25,4	1,006 31	1,005 38	1,005 13
25,6	1,006 55	1,005 79	1,005 33
25,8	1,006 80	1,006 00	1,005 53

TABLE 2 (*concluded*)

t °C	Benzene	Toluene	Xylene
26,0	1,007 04	1,006 22	1,005 73
26,2	1,007 28	1,006 43	1,005 92
26,4	1,007 52	1,006 65	1,006 12
26,6	1,007 77	1,006 86	1,006 32
26,8	1,008 01	1,007 07	1,006 52
27,0	1,008 25	1,007 29	1,006 72
27,2	1,008 50	1,007 50	1,006 91
27,4	1,008 74	1,007 72	1,007 11
27,6	1,008 98	1,007 93	1,007 31
27,8	1,009 23	1,008 14	1,007 51
28,0	1,009 47	1,008 36	1,007 71
28,2	1,009 72	1,008 57	1,007 91
28,4	1,009 96	1,008 79	1,008 11
28,6	1,010 21	1,009 00	1,008 31
28,8	1,010 45	1,009 22	1,008 50
29,0	1,010 69	1,009 43	1,008 70
29,2	1,010 94	1,009 85	1,008 90
29,4	1,011 19	1,009 86	1,009 10
29,6	1,011 43	1,010 08	1,009 30
29,8	1,011 68	1,010 29	1,009 50

7 HYDROMETER METHOD

7.1 Apparatus

7.1.1 Density hydrometer, constructed of soda-lime glass, complying with series L50 of ISO 649, calibrated for the determination of density at 20 °C, for use in liquids of low surface tension.

The hydrometer shall be examined before use to see that there has been no displacement of the paper scale. Any displacement can be detected by reference to the means provided for this purpose, for example a horizontal line etched on the stem and the corresponding datum line marked on the paper scale. If the corresponding scale has been displaced, the hydrometer shall be re-certified.

The readings of a hydrometer depend to some extent on the surface tension of the liquid in which the instrument is used, but internationally standardized hydrometers, series L50, are calibrated at surface tensions appropriate to the products covered by this International Standard, and respond little, in relation to the sub-division of their respective scales, to such differences in surface tension as occur in these liquids. Reference should be made to ISO 387 and ISO 649 for further information on hydrometry.

7.1.2 Hydrometer vessel, cylindrical, made of glass, free from local irregularities producing distortion, and several millimetres greater in diameter than the hydrometer bulb diameter; a 1 000 ml measuring cylinder is suitable.

7.1.3 Thermometers, complying with the requirements given in the annex, for the vessel (7.1.2).

7.2 Procedure

Fill the clean hydrometer vessel (7.1.2) to a sufficient depth with the sample (see clause 5) so that the hydrometer will not touch the bottom of the vessel when it is immersed in the sample. To avoid the formation of air bubbles, pour the sample down the sides of the vessel. Stir the sample, again avoiding the formation of air bubbles. Hold the hydrometer by the top of the stem, insert it carefully into the sample and release it when approximately in the position of equilibrium. A little experience soon enables the user to estimate when the hydrometer is approaching equilibrium and to release it in such a position that it rises or falls only by a small amount when released.

Note the approximate reading and lightly press down on the top of the hydrometer stem so that the stem is immersed a few millimetres more. Withdraw the hand and note the reading when the hydrometer is steady after a few oscillations about the equilibrium position. Observe the meniscus during this period. If the stem and liquid surface are clean, the meniscus shape will remain unchanged during the hydrometer movement; if the meniscus shape changes, the hydrometer should be cleaned. Record the hydrometer reading and also the temperature of the sample.

The reading corresponds to the plane of intersection of the horizontal liquid surface with the stem, determined by viewing the scale through the liquid and raising the line of sight to bring it into the plane of the liquid surface.

Calculate the corrected hydrometer reading, R_t, as follows:

$$R_t = R + C$$

where

R is the hydrometer reading;

C is the correction, obtained from the calibration certificate.

7.3 Calculation of density

Calculate the density, ρ_{20}, in grams per millilitre, of the sample at 20 °C as follows :

$$\rho_{20} = R_t \times M_3$$

where

R_t is the corrected hydrometer reading, calculated in accordance with 7.2;

M_3 is the multiplication factor, obtained from table 3 as a function of t;

t is the sample temperature, in degrees Celsius.

7.4 Precision

The precision of the test method, as obtained by statistical examination of interlaboratory results obtained for benzene, toluene and xylene, is as follows :

7.4.1 *Repeatability (r)*

The value below which the absolute difference between two single test results, on identical test material, obtained by one operator in one laboratory using the same equipment within a short interval of time applying the standardized test method, may be expected to lie with a 95 % probability, is 0,000 3 g/ml.

7.4.2 *Reproducibility (R)*

The value below which the absolute difference between two single test results, on identical test material, obtained by operators in different laboratories, applying the standardized test method, may be expected to lie with a 95 % probability, is 0,000 45 g/ml.

8 TEST REPORT

The test report shall include at least the following information :

a) the type and identification of the product tested;

b) a reference to this International Standard;

c) the result of the test;

d) any deviation, by agreement or otherwise, from the procedure specified;

e) the date of the test.

TABLE 3 — **Multiplication factors M_3 for conversion of corrected hydrometer reading at t °C to density at 20 °C**

t °C	Benzene	Toluene	Xylene
10,0	0,988 57	0,989,76	0,990 63
10,2	0,988 80	0,989 96	0,990 82
10,4	0,989 02	0,990 17	0,991 00
10,6	0,989 24	0,990 37	0,991 19
10,8	0,989 47	0,990 57	0,991 37
11,0	0,989 69	0,990 78	0,991 56
11,2	0,989 92	0,990 98	0,991 74
11,4	0,990 14	0,991 18	0,991 93
11,6	0,990 37	0,991 19	0,992 11
11,8	0,990 60	0,991 59	0,992 30
12,0	0,990 82	0,991 79	0,992 48
12,2	0,991 05	0,992 00	0,992 67
12,4	0,991 27	0,992 20	0,992 85
12,6	0,991 50	0,992 40	0,993 04
12,8	0,991 73	0,992 61	0,993 23
13,0	0,991 95	0,992 81	0,993 41
13,2	0,992 18	0,993 02	0,993 60
13,4	0,992 41	0,993 22	0,993 79
13,6	0,992 64	0,993 42	0,993 97
13,8	0,992 86	0,993 63	0,994 16
14,0	0,993 09	0,993 83	0,994 34
14,2	0,993 32	0,994 04	0,994 53
14,4	0,993 55	0,994 24	0,994 72
14,6	0,993 77	0,994 44	0,994 91
14,8	0,994 00	0,994 65	0,995 09
15,0	0,994 23	0,994 85	0,995 28
15,2	0,994 46	0,995 06	0,995 47
15,4	0,994 69	0,995 26	0,995 66
15,6	0,994 92	0,995 47	0,995 84
15,8	0,995 15	0,995 67	0,996 03
16,0	0,995 38	0,995 88	0,996 22
16,2	0,995 61	0,996 08	0,996 41
16,4	0,995 84	0,996 29	0,996 60
16,6	0,996 07	0,996 50	0,996 78
16,8	0,996 30	0,996 70	0,996 97
17,0	0,996 53	0,996 91	0,997 16
17,2	0,996 76	0,997 11	0,997 35
17,4	0,996 99	0,997 32	0,997 54
17,6	0,997 22	0,997 52	0,997 73
17,8	0,997 45	0,997 73	0,997 92

TABLE 3 (*continued*)

t °C	Benzene	Toluene	Xylene
18,0	0,997 68	0,997 94	0,998 10
18,2	0,997 91	0,998 14	0,998 29
18,4	0,998 14	0,998 35	0,998 43
18,6	0,998 37	0,998 55	0,998 67
18,8	0,998 61	0,998 76	0,998 86
19,0	0,998 84	0,998 97	0,999 05
19,2	0,999 07	0,999 17	0,999 24
19,4	0,999 30	0,999 38	0,999 43
19,6	0,999 53	0,999 59	0,999 62
19,8	0,999 77	0,999 79	0,999 81
20,0	1,000 00	1,000 00	1,000 00
20,2	1,000 23	1,000 21	1,000 19
20,4	1,000 47	1,000 41	1,000 38
20,6	1,000 70	1,000 62	1,000 57
20,8	1,000 93	1,000 83	1,000 76
21,0	1,001 17	1,001 04	1,000 95
21,2	1,001 40	1,001 24	1,001 14
21,4	1,001 64	1,001 45	1,001 33
21,6	1,001 87	1,001 66	1,001 52
21,8	1,002 10	1,001 87	1,001 72
22,0	1,002 34	1,002 07	1,001 91
22,2	1,002 57	1,002 28	1,002 10
22,4	1,002 81	1,002 49	1,002 29
22,6	1,003 04	1,002 70	1,002 48
22,8	1,003 28	1,002 91	1,002 67
23,0	1,003 51	1,003 11	1,002 87
23,2	1,003 75	1,003 32	1,003 06
23,4	1,003 99	1,003 53	1,003 25
23,6	1,004 22	1,003 74	1,003 44
23,8	1,004 46	1,003 95	1,003 63
24,0	1,004 69	1,004 16	1,003 83
24,2	1,004 93	1,004 37	1,004 02
24,4	1,005 17	1,004 57	1,004 21
24,6	1,005 40	1,004 78	1,004 40
24,8	1,005 64	1,004 99	1,004 60
25,0	1,005 88	1,005 20	1,004 79
25,2	1,006 12	1,005 41	1,004 98
25,4	1,006 35	1,005 62	1,005 18
25,6	1,006 59	1,005 83	1,005 37
25,8	1,006 83	1,006 04	1,005 56