



## Viscosity of liquids: Halogenated methanes

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## VISCOSITY OF LIQUIDS: HALOGENATED METHANES

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Data sheets for each of the liquids are given in the following order:

| Formula | Name | Alternative Name(s) |
|---------|------|---------------------|
|---------|------|---------------------|

#### MONOHALOMETHANES

|    |                    |               |                 |                  |   |
|----|--------------------|---------------|-----------------|------------------|---|
| 1. | CH <sub>3</sub> Cl | Chloromethane | Methyl chloride | Refrigerant 40   | 7 |
| 2. | CH <sub>3</sub> Br | Bromomethane  | Methyl bromide  | Refrigerant 40B1 | 8 |
| 3. | CH <sub>3</sub> I  | Iodomethane   | Methyl iodide   |                  | 9 |

#### DIHALOMETHANES

|    |                                 |                     |                          |                                       |    |
|----|---------------------------------|---------------------|--------------------------|---------------------------------------|----|
| 4. | CH <sub>2</sub> F <sub>2</sub>  | Difluoromethane     | Methylene difluoride     | Methylene fluoride<br>Refrigerant 32  | 10 |
| 5. | CH <sub>2</sub> ClF             | Chlorofluoromethane | Methylene chlorofluoride | Refrigerant 31                        | 11 |
| 6. | CH <sub>2</sub> Cl <sub>2</sub> | Dichloromethane     | Methylene dichloride     | Methylene chloride<br>Refrigerant 30  | 12 |
| 7. | CH <sub>2</sub> BrCl            | Bromochloromethane  | Methylene bromochloride  | Refrigerant 30B1                      | 14 |
| 8. | CH <sub>2</sub> Br <sub>2</sub> | Dibromomethane      | Methylene dibromide      | Methylene bromide<br>Refrigerant 30B2 | 15 |
| 9. | CH <sub>2</sub> I <sub>2</sub>  | Diiodomethane       | Methylene diiodide       | Methylene iodide                      | 16 |

Formula      Name      Alternative Name(s)

TRIHALOMETHANES

|     |                     |                       |            |                  |    |
|-----|---------------------|-----------------------|------------|------------------|----|
| 10. | CHF <sub>3</sub>    | Trifluoromethane      | Fluoroform | Refrigerant 23   | 17 |
| 11. | CHClF <sub>2</sub>  | Chlorodifluoromethane |            | Refrigerant 22   | 18 |
| 12. | CHBrF <sub>2</sub>  | Bromodifluoromethane  |            | Refrigerant 22B1 | 19 |
| 13. | CHCl <sub>2</sub> F | Dichlorofluoromethane |            | Refrigerant 21   | 20 |
| 14. | CHCl <sub>3</sub>   | Trichloromethane      | Chloroform | Refrigerant 20   | 21 |
| 15. | CHBr <sub>3</sub>   | Tribromomethane       | Bromoform  | Refrigerant 20B3 | 22 |

TETRAHALOMETHANES

|     |                                 |                            |                      |                  |    |
|-----|---------------------------------|----------------------------|----------------------|------------------|----|
| 16. | CF <sub>4</sub>                 | Tetrafluoromethane         | Carbon tetrafluoride | Refrigerant 14   | 23 |
| 17. | CClF <sub>3</sub>               | Chlorotrifluoromethane     |                      | Refrigerant 13   | 24 |
| 18. | CBrF <sub>3</sub>               | Bromotrifluoromethane      |                      | Refrigerant 13B1 | 25 |
| 19. | CCl <sub>2</sub> F <sub>2</sub> | Dichlorodifluoromethane    |                      | Refrigerant 12   | 26 |
| 20. | CBrClF <sub>2</sub>             | Bromochlorodifluoromethane |                      | Refrigerant 12B1 | 27 |
| 21. | CBr <sub>2</sub> F <sub>2</sub> | Dibromodifluoromethane     |                      | Refrigerant 12B2 | 28 |
| 22. | CCl <sub>3</sub> F              | Trichlorofluoromethane     |                      | Refrigerant 11   | 29 |
| 23. | CCl <sub>4</sub>                | Tetrachloromethane         | Carbon tetrachloride | Refrigerant 10   | 30 |
| 24. | CBrCl <sub>3</sub>              | Bromotrichloromethane      |                      | Refrigerant 10B1 | 31 |
| 25. | CBr <sub>4</sub>                | Tetrabromomethane          | Carbon tetrabromide  | Refrigerant 10B4 | 32 |

|                         |    |
|-------------------------|----|
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## VISCOSITY OF LIQUIDS: HALOGENATED METHANES

### 1. INTRODUCTION

This Item presents values for the viscosity at saturation pressure, in tabular form, for liquid halogenated methanes. The range covered is from just above the melting temperature to about 0.9 times the critical temperature.

The values given are based on data which are believed to be the most reliable available and have been reviewed and suitably extended. In common with other Items, quantities are expressed in SI units and conversion factors to other units are provided in Section 3.

Section 4 gives the procedure used to obtain the values of viscosity presented and indicates the effect of pressure. Section 5 gives an explanation of the Tables and indicates the uncertainties in the values presented.

Appendix A provides a complete bibliography of data sources for this Item. Data sources for individual compounds are listed on the appropriate Data Sheet.

### 2. NOTATION AND UNITS

The SI unit of dynamic viscosity is the newton second per square metre ( $\text{N s/m}^2$ ). The values presented in the tables are given in millinewton second per square metre ( $\text{mN s/m}^2$ ), a submultiple which is convenient for the magnitudes considered and which is equal to the c.g.s. centipoise (cP).

|          |                                                                |                        |
|----------|----------------------------------------------------------------|------------------------|
| $A, B$   | dimensionless constants for each liquid in Equation (4.1)      | -                      |
| $C$      | constant for each liquid in Equation (4.2)                     | K                      |
| $D$      | constant for each liquid in Equation (4.1)                     | $\text{mN s/m}^2$      |
| $p$      | pressure                                                       | $\text{N/m}^2$ (Pa)    |
| $T$      | kelvin temperature                                             | K                      |
| $t$      | Celsius temperature, $T - 273.15$                              | $^{\circ}\text{C}$     |
| $\alpha$ | constant in Equation (4.3)                                     | $\text{m}^2/\text{N}$  |
| $\eta$   | dynamic viscosity                                              | $\text{mN s/m}^2$ (cP) |
| $\theta$ | dimensionless temperature dependent variable in Equation (4.2) | -                      |

#### Subscripts

|     |                                                |
|-----|------------------------------------------------|
| $c$ | denotes value at the critical point            |
| $p$ | denotes value at pressure $p$                  |
| $r$ | denotes reduced quantity, e.g. $T_r = T/T_c$ . |

## 3. CONVERSION FACTORS

$$\begin{aligned}
 1 \text{ mN s/m}^2 &= 1 \text{ centipoise} \\
 &= 145.04 \times 10^{-9} \text{ lbf s/in}^2 \\
 &= 101.97 \times 10^{-6} \text{ kgf s/m}^2 \\
 &= 10^{-3} \text{ kg/m s}
 \end{aligned}$$

$$\begin{aligned}
 10^5 \text{ Pa} &= 1 \text{ bar} \\
 &= 14.5038 \text{ lbf/in}^2 \\
 &= 1.0197 \text{ kgf/cm}^2 \\
 &= 0.9869 \text{ atm} \\
 &= 750.062 \text{ mmHg.}
 \end{aligned}$$

## 4. LIQUID VISCOSITY

### 4.1 Viscosity at Saturation Pressure

The two equations most commonly used to describe variations of viscosity with temperature at saturation pressure are:

$$\ln \eta = A' + \frac{B'}{T},$$

$$\text{and} \quad \ln \eta = A'' + \frac{B''}{T - C''}.$$

Both of these can provide adequate representations of viscosity over limited ranges of temperature but are unsatisfactory over the full range. The first form often produces large deviations near the melting temperature or at higher viscosities, and neither is realistic for near-critical temperatures. Several equations are available which use molar volume as an independent variable but these are limited by the need for accurate volumetric data or an equation of state.

The following equation (Reference 1), which has been used for the present work has been found to give a good representation of the data from the melting temperature to  $T_r = 0.9$ :

$$\ln \frac{\eta}{D} = A(\theta - 1)^{1/3} + B(\theta - 1)^{4/3}, \quad (4.1)$$

$$\text{where} \quad \theta = \frac{T_c - C}{T - C}. \quad (4.2)$$

Relatively few reliable data are available at reduced temperatures greater than 0.9; however, the equation form is consistent with observed trends in that region and produces reasonable estimates close to the critical temperature.

The critical temperatures for these substances have been taken from ESDU 90015 (Reference 2). The derived values for the constants  $A$ ,  $B$ ,  $C$  and  $D$  are given in Table 7.1. The constant  $C$ , which has the dimensions of temperature is much lower in value than the melting temperature. The constant  $D$  is in effect a pseudo-critical viscosity, which is produced by the equation at the critical point. Values for  $D$  were determined from viscosities close to the critical point where available. Otherwise, the constants were all

obtained by fitting Equation (4.1) to reliable liquid viscosity data. In view of the uncertainties in the experimental data, and the deviations between different data sets for certain compounds, it was found that different sets of constants gave equally acceptable data fits in some cases. Values for the constants were chosen so as to give a good correlation with corresponding values for other members of each chemical series, whilst maintaining an acceptable fit to the data for the compound under study. In this way a set of viscosity values was produced, which varied consistently within a given chemical series.

## 4.2 Effect of Pressure

No accurate general expression is available for estimating the effect of pressure on the viscosity of these liquids. However, the simple expression given for *n*-alkanes in ESDU 79027 (Reference 1) applies to these liquids under similar conditions and is reproduced here as an approximate guide.

The viscosity of liquids with high viscosity at saturation pressure increases more rapidly with pressure than that of liquids with a low viscosity at saturation pressure. In most cases, the viscosity increases by about 1 per cent for a pressure increase of 1 MPa (10 bar). Below the normal boiling point, the difference between values measured at atmospheric pressure and those at saturation is therefore very small.

For liquids from the melting temperature to about  $0.75T_c$ , the following relationship may be used as an approximate guide:

$$\ln \frac{\eta_p}{\eta} = \alpha p, \quad (4.3)$$

where  $\eta_p$  is the viscosity at pressure  $p$ ,  $\eta$  is the viscosity at saturation pressure, and  $\alpha$  is a pressure-viscosity coefficient. The average value for  $\alpha$  is  $1 \times 10^{-8} \text{ m}^2/\text{N}$  for pressures up to 50 MPa. For liquids in general, the higher the viscosity at saturation pressure, the higher the value of  $\alpha$ .

## 5. EXPLANATION OF TABLES

The values of  $A$ ,  $B$ ,  $C$  and  $D$  to be used in Equations (4.1) and (4.2) are given in Table 7.1 together with the critical temperature and the range of applicability.

Values of the viscosity of individual compounds are given on separate sheets at 10 kelvin intervals with temperatures in K and °C. Extrapolated values are indicated in parenthesis. The sources of data used to derive the correlation are listed. Other earlier or less reliable sources were considered but not included.

Experimental data from the most reliable sources have an estimated accuracy of  $\pm 1\%$ . However, such data are few in number and are generally restricted to temperatures close to ambient. No such data were available for any of the compounds in this Item. The highest accuracy band is set at  $\pm 2\%$  for carbon tetrachloride between 300 and 313.15 K.

For many of these compounds, data from different sources differ widely, especially for low viscosities. Whilst it is considered that the procedure adopted here reduces the errors in the values presented to a minimum, it is recommended that the user allows for uncertainties as indicated in the Tables. In general these are  $\pm 5\%$  for temperatures near ambient but may reach  $\pm 20\%$ ,  $\pm 30\%$  or  $\pm 40\%$  in some cases, elsewhere.

## 6. REFERENCES

The references given are recommended sources of information supplementary to that in this Item.

1. ESDU Viscosity of liquids: Aliphatic hydrocarbons Part 1. Alkanes. Data Item 79027, ESDU International plc, London, UK, 1979.
2. ESDU Vapour pressures and critical points of liquids: Halogenated methanes. Data Item 90015, ESDU International plc, London, UK, 1990.

## 7. TABLES

TABLE 7.1 Constants for Equations (4.1) and (4.2)

| Compound                       | $T_c$  | $A$ | $B$   | $C$   | $D$                 | Range of Applicability<br>°C |
|--------------------------------|--------|-----|-------|-------|---------------------|------------------------------|
|                                | K      |     |       | K     | mN s/m <sup>2</sup> |                              |
| 1. Chloromethane               | 416.3  | 1.3 | 1.057 | 52.04 | 0.0420              | -90 to 110                   |
| 2. Bromomethane                | 463.   | 1.4 | 0.519 | 57.88 | 0.0640              | -90 to 130                   |
| 3. Iodomethane                 | 527.   | 1.8 | 0.334 | 65.88 | 0.0559              | -60 to 200                   |
| 4. Difluoromethane             | 351.5  | 2.1 | 0.688 | 43.94 | 0.0365              | -130 to 40                   |
| 5. Chlorodifluoromethane       | 428.   | 2.1 | 0.330 | 53.50 | 0.0387              | -130 to 110                  |
| 6. Dichloromethane             | 510.   | 2.1 | 0.308 | 63.75 | 0.0416              | -90 to 190                   |
| 7. Bromochloromethane          | 560.   | 2.1 | 0.276 | 70.00 | 0.0510              | -80 to 230                   |
| 8. Dibromomethane              | 610.   | 2.1 | 0.250 | 76.25 | 0.0633              | -40 to 270                   |
| 9. Diiodomethane               | 750.   | 2.1 | 0.272 | 93.75 | 0.0749              | 10 to 410                    |
| 10. Trifluoromethane           | 299.3  | 2.3 | 0.437 | 37.41 | 0.0325              | -150 to -10                  |
| 11. Chlorodifluoromethane      | 369.3  | 2.3 | 0.280 | 46.16 | 0.0352              | -140 to 60                   |
| 12. Bromodifluoromethane       | 413.   | 2.3 | 0.215 | 51.62 | 0.0490              | -120 to 100                  |
| 13. Dichlorodifluoromethane    | 451.25 | 2.3 | 0.275 | 56.41 | 0.0377              | -130 to 130                  |
| 14. Trichloromethane           | 536.5  | 2.3 | 0.290 | 67.06 | 0.0390              | -60 to 210                   |
| 15. Tribromomethane            | 685.   | 2.3 | 0.286 | 85.63 | 0.0607              | 20 to 340                    |
| 16. Tetrafluoromethane         | 227.7  | 2.5 | 0.300 | 28.46 | 0.0210              | -180 to -70                  |
| 17. Chlorotrifluoromethane     | 302.15 | 2.5 | 0.224 | 37.77 | 0.0286              | -170 to 0                    |
| 18. Bromotrifluoromethane      | 340.15 | 2.5 | 0.152 | 42.52 | 0.0380              | -160 to 30                   |
| 19. Dichlorodifluoromethane    | 385.05 | 2.5 | 0.210 | 48.13 | 0.0334              | -150 to 70                   |
| 20. Bromochlorodifluoromethane | 426.9  | 2.5 | 0.266 | 53.36 | 0.0375              | -150 to 110                  |
| 21. Dibromodifluoromethane     | 471.   | 2.5 | 0.214 | 58.88 | 0.0452              | -130 to 150                  |
| 22. Trichlorodifluoromethane   | 471.15 | 2.5 | 0.323 | 58.89 | 0.0351              | -100 to 150                  |
| 23. Tetrachloromethane         | 556.3  | 2.5 | 0.514 | 69.54 | 0.0366              | -10 to 220                   |
| 24. Bromotrichloromethane      | 606.   | 2.5 | 0.549 | 75.75 | 0.0398              | 0 to 270                     |
| 25. Tetrabromomethane          | 740.   | 2.5 | 0.781 | 92.50 | 0.0530              | 100 to 390                   |

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## CH<sub>3</sub>Cl CHLOROMETHANE (METHYL CHLORIDE, REFRIGERANT 40)

$$\ln(\eta/D) = A(\theta - 1)^{1/3} + B(\theta - 1)^{4/3}$$

$$\text{where } \theta = (T_c - C)/(T - C)$$

$\eta$  = viscosity at saturation pressure (mN s/m<sup>2</sup>)

$$T_c = 416.3 \text{ K}$$

$$A = 1.3, \quad B = 1.057, \quad C = 52.04, \quad D = 0.0420$$

| $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% |
|----------|-------------------------------|---------------------------|----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|
| 180      | (2.270)                       | 30                        | 290      | 0.1895                        | 5                         | -90       | (1.978)                       | 30                        | 20        | 0.1828                        | 5                         |
| 190      | (1.504)                       | 30                        | 300      | 0.1695                        | 5                         | -80       | (1.339)                       | 30                        | 30        | 0.1639                        | 5                         |
| 200      | (1.061)                       | 20                        | 310      | 0.1528                        | 5                         | -70       | (0.961)                       | 20                        | 40        | 0.1481                        | 5                         |
| 210      | (0.787)                       | 20                        | 320      | 0.1387                        | 5                         | -60       | (0.722)                       | 20                        | 50        | 0.1346                        | 5                         |
| 220      | (0.607)                       | 10                        | 330      | 0.1265                        | 5                         | -50       | (0.563)                       | 10                        | 60        | 0.1230                        | 5                         |
| 230      | (0.484)                       | 10                        | 340      | 0.1159                        | 5                         | -40       | (0.453)                       | 10                        | 70        | 0.1128                        | 5                         |
| 240      | (0.396)                       | 10                        | 350      | 0.1065                        | 5                         | -30       | (0.373)                       | 10                        | 80        | 0.1037                        | 5                         |
| 250      | (0.331)                       | 10                        | 360      | 0.0980                        | 5                         | -20       | (0.314)                       | 10                        | 90        | 0.0955                        | 5                         |
| 260      | (0.282)                       | 5                         | 370      | 0.0902                        | 5                         | -10       | (0.269)                       | 5                         | 100       | 0.0879                        | 5                         |
| 270      | (0.244)                       | 5                         | 380      | 0.0829                        | 5                         | 0         | (0.234)                       | 5                         | 110       | 0.0807                        | 5                         |
| 280      | 0.2139                        | 5                         |          |                               |                           | 10        | 0.2056                        | 5                         |           |                               |                           |

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## CH<sub>3</sub>Br BROMOMETHANE (METHYL BROMIDE, REFRIGERANT 40B1)

$$\ln(\eta/D) = A(\theta - 1)^{1/3} + B(\theta - 1)^{4/3}$$

$$\text{where } \theta = (T_c - C)/(T - C)$$

$\eta$  = viscosity at saturation pressure (mN s/m<sup>2</sup>)

$$T_c = 463. \text{ K}$$

$$A = 1.4, \quad B = 0.519, \quad C = 57.88, \quad D = 0.0640$$

| $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% |
|----------|-------------------------------|---------------------------|----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|
| 180      | (2.004)                       | 20                        | 300      | 0.2965                        | 5                         | -90       | (1.817)                       | 20                        | 30        | 0.2889                        | 5                         |
| 190      | (1.492)                       | 20                        | 310      | 0.2734                        | 5                         | -80       | (1.373)                       | 20                        | 40        | 0.2667                        | 5                         |
| 200      | (1.161)                       | 10                        | 320      | 0.2532                        | 5                         | -70       | (1.081)                       | 10                        | 50        | 0.2474                        | 5                         |
| 210      | (0.935)                       | 10                        | 330      | 0.2354                        | 5                         | -60       | (0.878)                       | 10                        | 60        | 0.2303                        | 5                         |
| 220      | (0.774)                       | 10                        | 340      | 0.2197                        | 5                         | -50       | (0.733)                       | 10                        | 70        | 0.2150                        | 5                         |
| 230      | (0.655)                       | 10                        | 350      | 0.2055                        | 5                         | -40       | (0.624)                       | 10                        | 80        | 0.2013                        | 5                         |
| 240      | 0.5648                        | 10                        | 360      | 0.1926                        | 5                         | -30       | 0.5408                        | 10                        | 90        | 0.1888                        | 5                         |
| 250      | 0.4944                        | 10                        | 370      | (0.181)                       | 5                         | -20       | 0.4754                        | 10                        | 100       | (0.177)                       | 5                         |
| 260      | 0.4383                        | 5                         | 380      | (0.170)                       | 5                         | -10       | 0.4230                        | 5                         | 110       | (0.167)                       | 5                         |
| 270      | 0.3927                        | 5                         | 390      | (0.160)                       | 5                         | 0         | 0.3801                        | 5                         | 120       | (0.156)                       | 5                         |
| 280      | 0.3550                        | 5                         | 400      | (0.150)                       | 10                        | 10        | 0.3445                        | 5                         | 130       | (0.147)                       | 10                        |
| 290      | 0.3234                        | 5                         |          |                               |                           | 20        | 0.3145                        | 5                         |           |                               |                           |

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## CH<sub>3</sub>I IODOMETHANE (METHYL IODIDE)

$$\ln(\eta/D) = A(\theta - 1)^{1/3} + B(\theta - 1)^{4/3}$$

$$\text{where } \theta = (T_c - C)/(T - C)$$

$\eta$  = viscosity at saturation pressure (mN s/m<sup>2</sup>)

$$T_c = 527. \text{ K}$$

$$A = 1.8, \quad B = 0.334, \quad C = 65.88, \quad D = 0.0559$$

| $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $T$<br>K | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% | $t$<br>°C | $\eta$<br>mN s/m <sup>2</sup> | Uncert.<br>in $\eta$<br>% |
|----------|-------------------------------|---------------------------|----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|-----------|-------------------------------|---------------------------|
| 210      | (1.510)                       | 20                        | 350      | (0.311)                       | 10                        | -60       | (1.416)                       | 20                        | 80        | (0.304)                       | 10                        |
| 220      | (1.243)                       | 10                        | 360      | (0.290)                       | 10                        | -50       | (1.175)                       | 10                        | 90        | (0.284)                       | 10                        |
| 230      | (1.047)                       | 10                        | 370      | (0.272)                       | 10                        | -40       | (0.996)                       | 10                        | 100       | (0.267)                       | 10                        |
| 240      | (0.898)                       | 10                        | 380      | (0.255)                       | 10                        | -30       | (0.858)                       | 10                        | 110       | (0.250)                       | 10                        |
| 250      | (0.782)                       | 10                        | 390      | (0.240)                       | 10                        | -20       | (0.751)                       | 10                        | 120       | (0.235)                       | 10                        |
| 260      | (0.690)                       | 5                         | 400      | (0.226)                       | 10                        | -10       | (0.664)                       | 5                         | 130       | (0.221)                       | 10                        |
| 270      | 0.6148                        | 5                         | 410      | (0.213)                       | 10                        | 0         | 0.5941                        | 5                         | 140       | (0.209)                       | 10                        |
| 280      | 0.5530                        | 5                         | 420      | (0.200)                       | 20                        | 10        | 0.5358                        | 5                         | 150       | (0.196)                       | 20                        |
| 290      | 0.5013                        | 5                         | 430      | (0.188)                       | 20                        | 20        | 0.4867                        | 5                         | 160       | (0.185)                       | 20                        |
| 300      | 0.4574                        | 5                         | 440      | (0.177)                       | 20                        | 30        | 0.4450                        | 5                         | 170       | (0.174)                       | 20                        |
| 310      | 0.4198                        | 5                         | 450      | (0.167)                       | 20                        | 40        | 0.4090                        | 5                         | 180       | (0.163)                       | 20                        |
| 320      | 0.3871                        | 5                         | 460      | (0.156)                       | 20                        | 50        | 0.3777                        | 5                         | 190       | (0.153)                       | 20                        |
| 330      | (0.358)                       | 5                         | 470      | (0.146)                       | 20                        | 60        | (0.350)                       | 5                         | 200       | (0.143)                       | 20                        |
| 340      | (0.333)                       | 10                        |          |                               |                           | 70        | (0.326)                       | 10                        |           |                               |                           |

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