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| **UN/SCEGHS/36/INF.37** |
| **Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals**  **5 December 2018** |

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| **Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals** |
| **Thirty-sixth session**  Geneva, 5-7 December 2018 |
| Item 3 (f) of the provisional agenda  **Classification criteria and related hazard communication:**  **aspiration hazard** |

Aspiration hazard – data on viscosity of mixtures

Submitted by the International Paint and Printing Ink Council (IPPIC)

1. This informal document provides some data in support of working document ST/SG/AC.10/C.4/2018/34 submitted by IPPIC for the thirty-sixth session of the GHS Sub-Committee, proposing amendments to Chapter 3.10 of the GHS.
2. This paper presents a limited selection of literature values for common solvents plus mixture test data provided by member companies for relevant products (paints, printing inks). Comparative data obtained at more than one temperature do not exist widely, in part because of the practical difficulties in testing this type of product at temperatures higher than ambient (for example separation of the paint, partial curing/polymerisation leading to blocking of the viscometer, etc.). Furthermore most paints and printing inks exhibit non-Newtonian fluid behaviour, which means that there is no simple relationship between temperature and viscosity.
3. Work is continuing to gather pertinent data from members and to conduct further measurements in order to support and substantiate the proposal, and if appropriate to derive a more accurate proposal for an uncertainty factor.

Literature values

Kinematic viscosity of organic liquids at different temperatures – sample data gathered from various sources

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| **Liquid** | **T (°C)** | *ν* **(mm2/s)** | **Difference in** *ν* **(at lower T vs. higher)** |
| Benzene | 23 | 0.721 | +25% |
| 40 | 0.578 |
| Acetone\* | 25 | 0.31 | +26% |
| 50 | 0.247 |
| Ethanol\* | 20 | 1.52 | +27% |
| 37.78 | 1.20 |
| Methanol\* | 25 | 0.543 | +39% |
| 50 | 0.392 |
| Allyl alcohol\* | 20 | 1.60 | +78% |
| 40 | 0.90 |

\* *Water-miscible solvents which do not fulfil the criteria for aspiration hazard (included for viscosity comparison only)*

Actual product measurements

1a. Measurements conducted by a paint manufacturer on the hardener component of a two-pack primer coating system. The measurements were made using a rotational viscometer at both 20°C and 40°C. The specific gravity (density) of the hardener was 0.89.   
  
The viscosity was also measured for transport using a flow cup in accordance with ISO 2431. The flow time was 8 seconds at 23°C (6mm jet).   
  
See tables on next page for results.

**Measurement @ 20°C:**

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| Point No. | Shear Rate | Time | Shear Stress | Viscosity | Torque | Viscosity | Temperature | **Kinematic Viscosity** | Rotational Speed |
| Constant component | **Constant component** | Constant component |
| [1/s] | [s] | [Pa] | [mPa·s] | [mN·m] | [Pa·s] | [°C] | **[mm²/s]** | [1/min] |
| 1 | 600 | 5 | 2.3029 | 3.8384 | 0.075428 | 0.0038384 | 19 | **4.312808989** | 100.27 |
| 2 | 600 | 10 | 2.2881 | 3.8135 | 0.074941 | 0.0038135 | 18.97 | **4.284831461** | 100.27 |
| 3 | 600 | 15 | 2.2968 | 3.828 | 0.075228 | 0.003828 | 18.95 | **4.301123596** | 100.27 |
| 4 | 600 | 20 | 2.2896 | 3.8159 | 0.07499 | 0.0038159 | 18.93 | **4.28752809** | 100.27 |
| 5 | 600 | 25 | 2.2929 | 3.8215 | 0.0751 | 0.0038215 | 18.91 | **4.293820225** | 100.27 |
| 6 | 600 | 30 | 2.3022 | 3.837 | 0.075405 | 0.003837 | 18.9 | **4.311235955** | 100.27 |
| 7 | 600 | 35 | 2.3026 | 3.8376 | 0.075416 | 0.0038376 | 18.89 | **4.311910112** | 100.27 |
| 8 | 600 | 40 | 2.3032 | 3.8387 | 0.075437 | 0.0038387 | 18.88 | **4.313146067** | 100.27 |
| 9 | 600 | 45 | 2.2959 | 3.8264 | 0.075196 | 0.0038264 | 18.87 | **4.299325843** | 100.27 |
| 10 | 600 | 50 | 2.3084 | 3.8474 | 0.075608 | 0.0038474 | 18.86 | **4.322921348** | 100.27 |

**Measurement @ 40°C:**

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| Point No. | Shear Rate | Time | Shear Stress | Viscosity | Torque | Viscosity | Temperature | **Kinematic Viscosity** | Rotational Speed |
| Constant component | **Constant component** | Constant component |
| [1/s] | [s] | [Pa] | [mPa·s] | [mN·m] | [Pa·s] | [°C] | **[mm²/s]** | [1/min] |
| 1 | 600 | 5 | 1.7293 | 2.8823 | 0.056641 | 0.0028823 | 40.07 | **3.238539326** | 100.27 |
| 2 | 600 | 10 | 1.7247 | 2.8745 | 0.056488 | 0.0028745 | 40.08 | **3.229775281** | 100.27 |
| 3 | 600 | 15 | 1.7197 | 2.8662 | 0.056325 | 0.0028662 | 40.08 | **3.220449438** | 100.27 |
| 4 | 600 | 20 | 1.7159 | 2.8599 | 0.056202 | 0.0028599 | 40.07 | **3.213370787** | 100.27 |
| 5 | 600 | 25 | 1.7045 | 2.8409 | 0.055828 | 0.0028409 | 40.07 | **3.192022472** | 100.27 |
| 6 | 600 | 30 | 1.7136 | 2.8561 | 0.056127 | 0.0028561 | 40.07 | **3.209101124** | 100.27 |
| 7 | 600 | 35 | 1.7365 | 2.8942 | 0.056877 | 0.0028942 | 40.07 | **3.251910112** | 100.27 |
| 8 | 600 | 40 | 1.7359 | 2.8931 | 0.056855 | 0.0028931 | 40.07 | **3.250674157** | 100.27 |
| 9 | 600 | 45 | 1.7416 | 2.9026 | 0.057042 | 0.0029026 | 40.06 | **3.261348315** | 100.27 |
| 10 | 600 | 50 | 1.7474 | 2.9124 | 0.057233 | 0.0029124 | 40.06 | **3.272359551** | 100.27 |

1b. Measurements made at 40°C (only) on the epoxy base component of the two-pack system. This mixture has a specific gravity of 1.23. The flow time (ISO 2431) was 22 seconds at 23°C (6mm jet).

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| Point No. | Shear Rate | Time | Shear Stress | Viscosity | Torque | Viscosity | Temperature | **Kinematic Viscosity** | Rotational Speed |
| Constant component | **Constant component** | Constant component |
| [1/s] | [s] | [Pa] | [mPa·s] | [mN·m] | [Pa·s] | [°C] | **[mm²/s]** | [1/min] |
| 1 | 600 | 5 | 31.939 | 53.234 | 1.0461 | 0.053234 | 39.8 | **43.2796748** | 100.27 |
| 2 | 600 | 10 | 31.748 | 52.913 | 1.0398 | 0.052913 | 39.76 | **43.01869919** | 100.27 |
| 3 | 600 | 15 | 31.636 | 52.727 | 1.0362 | 0.052727 | 39.72 | **42.86747967** | 100.27 |
| 4 | 600 | 20 | 31.618 | 52.696 | 1.0356 | 0.052696 | 39.68 | **42.84227642** | 100.27 |
| 5 | 600 | 25 | 31.606 | 52.677 | 1.0352 | 0.052677 | 39.66 | **42.82682927** | 100.27 |
| 6 | 600 | 30 | 31.658 | 52.764 | 1.0369 | 0.052764 | 39.65 | **42.89756098** | 100.27 |
| 7 | 600 | 35 | 31.739 | 52.898 | 1.0395 | 0.052898 | 39.65 | **43.00650407** | 100.27 |
| 8 | 600 | 40 | 31.892 | 53.154 | 1.0446 | 0.053154 | 39.65 | **43.21463415** | 100.27 |
| 9 | 600 | 45 | 32.112 | 53.52 | 1.0518 | 0.05352 | 39.66 | **43.51219512** | 100.27 |
| 10 | 600 | 50 | 32.438 | 54.065 | 1.0625 | 0.054065 | 39.68 | **43.95528455** | 100.27 |

2. Measurements made at 20°C (only) on a second epoxy primer base, but of higher viscosity. This mixture has a specific gravity of 1.64 and a flow time (ISO 2431) of > 60 seconds at 23°C (6mm jet).

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| Point No. | Shear Rate | Time | Shear Stress | Viscosity | Torque | Viscosity | Temperature | **Kinematic Viscosity** | Rotational Speed |
| Constant component | **Constant component** | Constant component |
| [1/s] | [s] | [Pa] | [mPa·s] | [mN·m] | [Pa·s] | [°C] | **[mm²/s]** | [1/min] |
| 1 | 1 | 10 | 50.913 | 50918 | 1.6676 | 50.918 | 19.99 | **31047.56098** | 0.16711 |
| 2 | 1.54 | 18.66 | 56.081 | 36417 | 1.8368 | 36.417 | 20 | **22205.4878** | 0.25736 |
| 3 | 2.37 | 26.16 | 60.245 | 25407 | 1.9732 | 25.407 | 20 | **15492.07317** | 0.39628 |
| 4 | 3.65 | 32.65 | 66.19 | 18128 | 2.1679 | 18.128 | 20 | **11053.65854** | 0.61022 |
| 5 | 5.62 | 38.28 | 72.308 | 12859 | 2.3683 | 12.859 | 20 | **7840.853659** | 0.93977 |
| 6 | 8.66 | 43.15 | 79.678 | 9200.9 | 2.6097 | 9.2009 | 20 | **5610.304878** | 1.4473 |
| 7 | 13.3 | 47.36 | 91.965 | 6895.4 | 3.0121 | 6.8954 | 20 | **4204.512195** | 2.229 |
| 8 | 20.5 | 51.02 | 108.67 | 5292.7 | 3.5591 | 5.2927 | 20 | **3227.256098** | 3.4312 |
| 9 | 31.6 | 54.18 | 131.8 | 4167.7 | 4.317 | 4.1677 | 20 | **2541.280488** | 5.2853 |
| 10 | 48.7 | 56.92 | 164.32 | 3375.4 | 5.382 | 3.3754 | 20 | **2058.170732** | 8.1358 |
| 11 | 75 | 59.29 | 211.67 | 2822.3 | 6.9329 | 2.8223 | 20 | **1720.914634** | 12.534 |
| 12 | 115 | 61.34 | 280.53 | 2429 | 9.1881 | 2.429 | 20 | **1481.097561** | 19.301 |
| 13 | 178 | 63.12 | 379.55 | 2134.7 | 12.432 | 2.1347 | 20 | **1301.646341** | 29.715 |
| 14 | 274 | 64.66 | 524.48 | 1915 | 17.178 | 1.915 | 20 | **1167.682927** | 45.77 |
| 15 | 422 | 65.99 | 737.56 | 1748.4 | 24.157 | 1.7484 | 20 | **1066.097561** | 70.5 |
| 16 | 650 | 67.15 | 1044.9 | 1608.7 | 34.225 | 1.6087 | 20.01 | **980.9146341** | 108.55 |
| 17 | 1000 | 68.15 | 1458.1 | 1456.6 | 47.756 | 1.4566 | 20 | **888.1707317** | 167.29 |

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3. Measurements made at 40°C (only) on an intermediate resin solution, comprising 60% rosin and 40% xylene. This mixture has a specific gravity of 1.01 and a flow time (ISO 2431) of 54 seconds at 23°C (6mm jet).

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| Point No. | Shear Rate | Time | Shear Stress | Viscosity | Torque | Viscosity | Temperature | **Kinematic Viscosity** | Rotational Speed |
| Constant component | **Constant component** | Constant component |
| [1/s] | [s] | [Pa] | [mPa·s] | [mN·m] | [Pa·s] | [°C] | **[mm²/s]** | [1/min] |
| 1 | 500 | 5 | 47.47 | 94.949 | 1.5548 | 0.094949 | 39.88 | **105.5** | 83.553 |
| 2 | 500 | 10 | 48.641 | 97.284 | 1.5931 | 0.097284 | 39.86 | **108.09** | 83.559 |
| 3 | 500 | 15 | 48.695 | 97.39 | 1.5949 | 0.09739 | 39.85 | **108.21** | 83.561 |
| 4 | 500 | 20 | 45.186 | 90.36 | 1.48 | 0.09036 | 39.85 | **100.4** | 83.572 |
| 5 | 500 | 25 | 45.359 | 90.718 | 1.4856 | 0.090718 | 39.85 | **100.8** | 83.561 |
| 6 | 500 | 30 | 45.456 | 90.914 | 1.4888 | 0.090914 | 39.86 | **101.02** | 83.561 |
| 7 | 500 | 35 | 45.804 | 91.608 | 1.5002 | 0.091608 | 39.86 | **101.79** | 83.561 |
| 8 | 500 | 40 | 46.495 | 92.992 | 1.5228 | 0.092992 | 39.87 | **103.32** | 83.559 |
| 9 | 500 | 45 | 47.887 | 95.774 | 1.5685 | 0.095774 | 39.89 | **106.42** | 83.562 |
| 10 | 500 | 50 | 45.992 | 91.982 | 1.5064 | 0.091982 | 39.91 | **102.2** | 83.562 |
| 11 | 500 | 55 | 46.312 | 92.625 | 1.5168 | 0.092625 | 39.92 | **102.92** | 83.56 |
| 12 | 500 | 60 | 46.546 | 93.093 | 1.5245 | 0.093093 | 39.94 | **103.44** | 83.561 |

1. Quality control measurements on various printing inks, all containing > 10% solvent naphtha (a hydrocarbon potentially qualifying the mixtures for aspiration hazard classification, subject to the viscosity).

Dynamic viscosity was measured at 20°C using a cone-and-plate viscometer (cone 3, 75 rpm) and the kinematic viscosity calculated using the density of the inks.

White pad printing ink: 4770 mPa·s /1,629 g/cm³ = **2928 mm²/s**

Black screen/pad printing ink: 3130 mPa·s / 0,983 g/cm³ = **3184 mm²/s**

Yellow screen printing ink: 3240 mPa·s / 1,13 g/cm³ = **2867 mm²/s**

The viscosities at 20°C are so high that it can be readily assumed without further testing that they will not fall below the level triggering classification at 40°C (20.5 or 14.5 mm²/s).