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Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

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Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals

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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

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:

Point No.	Shear Rate	Time	Shear Stress	Viscosity	Torque	Viscosity Constant component	Temperature	**Kinematic Viscosity Constant component**	Rotational Speed 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:

Point No.	Shear Rate	Time	Shear Stress	Viscosity	Torque	Viscosity Constant component	Temperature	**Kinematic Viscosity Constant component**	Rotational Speed 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).

Point No.	Shear Rate	Time	Shear Stress	Viscosity	Torque	Viscosity Constant component	Temperature	**Kinematic Viscosity Constant component**	Rotational Speed 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).

Point No.	Shear Rate	Time	Shear Stress	Viscosity	Torque	Viscosity Constant component	Temperature	**Kinematic Viscosity Constant component**	Rotational Speed 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

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).

Point No.	Shear Rate	Time	Shear Stress	Viscosity	Torque	Viscosity Constant component	Temperature	**Kinematic Viscosity Constant component**	Rotational Speed 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

4. 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).