GUIDANCE NOTE No. 56

DETERMING THE CORRECT ULLAGE FOR PACKAGES CONTAINING FLAMMABLE SOLVENTS

Solvents are distributed in a variety of packages, designed for transportation and to be strong enough to withstand the shocks and loadings normally encountered during carriage, including trans-shipment between transport units, warehouses etc.

The design specification for approved packaging may be found in ADR. The European Agreement concerning the International Carriage of Dangerous Goods by Road and a requirement of these regulations is to ensure sufficient ullage is left in the packaging after completion of the filling process. Special consideration is given to low boiling point liquids where the cubic expansion of the liquid as a result of a rise in temperature can lead to distortion of the package and leaks. Selecting the correct percentage of fill to achieve the necessary ullage will prevent the unintentional release of a dangerous substance that could occur as a result of over pressure.

Packaging for dangerous goods generally conforms to "standard" sizes based on intended fill volumes, such as 25 litre, 205 litre and 1000 litre, commonly referred to as a can, drum or an IBC* (Intermediate Bulk Container). These packages will have a nominal capacity which is designed to provide sufficient ullage for liquids with a boiling point > 300^{O}C when filled to the recognised pack size. Therefore a drum with a nominal fill capacity of 210 litres can be filled with a liquid whose boiling point is above 300^{O}C to a maximum of 98% or 205 Litres. However, the brimful capacity of a container is normally above the nominal capacity thereby allowing for additional space for further expansion of the liquid.

ADR refers to the capacity of the container without defining whether it is the nominal or the brimful capacity. Custom and practice in the UK has determined that capacity as outlined in ADR means maximum or brimful capacity, and uses this measure when determining maximum fill volumes for low boiling point liquids.

In recent years, changes in pack size due to rising raw material costs and environmentally based packaging regulations has led to a reduction in the brimful capacity of packagings whilst maintaining the "nominal" capacity. Market indications are the brimful capacity of new drums may have reduced from 220 & 218 litres down to around 216.4 litres. This change has

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meant that many historical fill volumes may now be incorrect and should be adjusted back into line with ADR. It is likely that similar changes will be required for other pack sizes.

Chapter 4.1 of ADR 2013 provides general provisions for the packing of dangerous goods in packages, including IBCs* and large packages. In order to ensure that neither leakage nor permanent distortion of the packaging occurs as a result of an expansion of the liquid caused by temperatures during transport, sufficient ullage must be present in the package.

- Liquids should not completely fill the container at a temperature of 55^{O}C
- Sufficient ullage shall be left in an IBC* to ensure that at the mean bulk temperature of 50^{O}C it is not filled > 98% of its water capacity.*
- For a filling temperature of 15^{O}C, the maximum degree of filling shall be determined as follows, unless otherwise provided, either:

  (a)

Boiling point (IBP) of the liquid in ^{O}C	<60	≥60 <100	≥100 < 200	≥200 <300	≥300
Degree of filling of the capacity of the package	90%	92%	94%	96%	98%

  or (b)

$$\text{degree of filling} = \frac{98}{1 + \alpha(50 - t_f)} \text{ \% of the capacity of the packaging}$$

  In this formula α represents the mean coefficient of cubic expansion of the liquid substance between 15^{O}C and 50^{O}C; that is to say, for a maximum rise in temperature of 35^{O}C, α is calculated according to the formula: $\alpha = \frac{d_{15} - d_{50}}{35 \times d_{50}}$

  d_{15} and d_{50} being the relative densities [1] of the liquid at 15^{O}C and 50^{O}C and t_f the mean temperature of the liquid at the time of filling.

The chart below provides some guidance how using table (a) above may affect the maximum degree of filling permissible for some of the more commonly used solvents based on the brimful capacity of a "205 litre" drum with a nominal capacity of 210 Litres and a brimful capacity of 216.4 litres.

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Product	Mean Coefficeint of expansion	Initial Boiling Point °c	Density of Product (@ 15°C H/C & 20°C OXY)	ADR %Fill	Container capacity 216.4		Container capacity 218.7		Container capacity 220.0	
					Volume based on % and capacity	Weight based on % and capacity	Volume based on % and capacity	Weight based on % and capacity	Volume based on % and capacity	Weight based on % and capacity
1-methoxy-2-propanol	0.0009	120	0.922	94	203.4	187.5	205.6	189.5	206.8	190.7
2-Methoxy-1-methylethyl acetate	0.0011	146	0.967	94	203.4	196.7	205.6	198.8	206.8	200
Acetone	0.0011	56	0.791	90	194.8	154.1	196.8	155.7	198	156.6
Butyl Glycol	0.0008	170	0.901	94	203.4	183.3	205.6	185.2	206.8	186.3
D.B.E.	0.001	183	1.088	94	203.4	221.3	205.6	223.7	206.8	225
Dipropylene Glycol Mono Methyl Ether	0.0007	185	0.951	94	203.4	193.4	205.6	195.5	206.8	196.7
Ethyl Acetate	0.0012	75	0.899	92	199.1	179	201.2	180.9	202.4	182
HYDROCARBONS, C10, aromatics,	0.0008	178	0.891	94	203.4	181.2	205.6	183.2	206.8	184.3
HYDROCARBONS, C10-C13, n-alkanes, isoalkanes, cyclics, <2% aromatics	0.0008	175	0.804	94	203.4	163.5	205.6	165.3	206.8	166.3
HYDROCARBONS, C11-14, n-alkanes, isoalkanes, cyclic, <2% aromatics	0.0007	200	0.803	96	207.7	166.8	210	168.6	211.2	169.6
HYDROCARBONS, C11-C13, isoalkanes, <2% aromatics	0.0007	184	0.768	94	203.4	156.2	205.6	157.9	206.8	158.8
HYDROCARBONS, C7 - C9, n-alkanes, isoalkanes, cyclics.	0.0009	102	0.76	94	203.4	154.6	205.6	156.2	206.8	157.2
HYDROCARBONS, C9 - C11, n-alkanes, isoalkanes, cyclics, <2% aromatics	0.0008	162	0.775	94	203.4	157.6	205.6	159.3	206.8	160.3
HYDROCARBONS, C9, aromatics	0.0008	155	0.875	94	203.4	178	205.6	179.9	206.8	181

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HYDROCARBONS, C9-12, n-alkanes, isoalkanes, cyclics, (2-25%) aromatics	0.0007	154	0.785	94	203.4	159.7	205.6	161.4	206.8	162.3
IDA 99	0.0008	78	0.793	92	199.1	157.9	201.2	159.6	202.4	160.5
iso Butanol	0.0008	106	0.802	94	203.4	163.1	205.6	164.9	206.8	165.9
Iso propanol	0.0008	78	0.785	92	199.1	156.3	201.2	157.9	202.4	158.9
Kerosine (petroleum), hydrodesulfurized	0.0007	180	0.808	94	203.4	164.4	205.6	166.1	206.8	167.1
Methanol	0.0009	64	0.798	92	199.1	158.9	201.2	160.6	202.4	161.5
Methyl Acetate	0.0012	56	0.934	90	194.8	181.9	196.8	183.8	198	184.9
Methyl Ethyl Ketone	0.0011	79	0.804	92	199.1	160.1	201.2	161.8	202.4	162.7
Methyl Iso Butyl Ketone	0.0009	114	0.801	94	203.4	162.9	205.6	164.7	206.8	165.6
Methylene Chloride	0.0018	39	1.331	90	194.8	259.2	196.8	262	198	263.5
Mono Propyl Glycol	0.0007	188	1.036	94	203.4	210.7	205.6	213	206.8	214.2
n. Butanol	0.0008	118	0.809	94	203.4	164.6	205.6	166.3	206.8	167.3
n. Butyl Acetate	0.0011	124	0.881	94	203.4	179.2	205.6	181.1	206.8	182.2

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n. Propanol	0.0008	97	0.803	92	199.1	159.9	201.2	161.6	202.4	162.5
n. Propyl Acetate	0.0011	102	0.888	94	203.4	180.6	205.6	182.6	206.8	183.6
S.B.P. 5	0.0009	94	0.695	92	199.1	138.4	201.2	139.8	202.4	140.7
T.S.D.A.	0.0008	78	0.791	92	199.1	157.5	201.2	159.2	202.4	160.1
Toluene	0.0009	111	0.872	94	203.4	177.4	205.6	179.3	206.8	180.3
Xylene	0.0009	137	0.87	94	203.4	177	205.6	178.9	206.8	179.9

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Consolidation within the drum manufacturing industry has led to some degree of standardisation on pack sizes but it is important to verify each manufacturer's specification to determine the correct maximum volume relevant to the package.

Solvents are often packed into reconditioned metal drums that will have had their tops removed to ensure effective laundering before a new top is fitted. This activity can lead to a reduction in size and the brimful capacity, but not the nominal capacity. Therefore the brimful capacity of a reconditioned drum is not certain and caution must be exercised when determining the maximum degree of filling.

A practicable solution would be to base the maximum degree of filling for reconditioned steel drums on the nominal capacity rather than the estimated brimful capacity.

This note is designed to provide some basic guidance on safe maximum filling volumes for liquids with boiling points below 300^{O}C, but reference should be made to Chapter 4.1 of the current ADR regulations for full details on the general provisions applicable to packing of dangerous goods in packages.

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