Formaldehyde Emissions – Understanding the standards.

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The Starting Point - Indoor Air Quality

Formaldehyde gas is emitted from a range of natural and man-made materials. Motor vehicles, combustion of many products and heating wood during drying all produce formaldehyde. Formaldehyde gas is also emitted from formaldehyde resins used in many wood based products, due to the release of unbound formaldehyde remaining after the pressing process and the ongoing hydrolysis of the cured resin.

The outdoor atmospheric concentration of formaldehyde gas is normally low because the gas breaks down quickly, although in heavy traffic continuous exhaust gases may produce high levels. In enclosed indoor spaces the formaldehyde levels may also be high - in a poorly ventilated room cigarette smoke can raise formaldehyde levels to several times the recommended maximum.

Formaldehyde has been linked to human health problems from both short and long term exposure to the gas.
To limit human exposure the World Health Organisation (WHO) has produced guidelines for maximum workplace and dwelling concentrations. Using the WHO recommendations, many countries have developed guidelines and regulations governing indoor air quality.

Specification Standards

In response to the recognised need to limit exposure to formaldehyde gas there are a number of "Specification Standards" which categorise wood based products into various emission classes. Sometimes these classes are given in the same standard as the test procedure, JIS A 5905 is an example of this. Others, such as AS/NZS 1859.1 for particleboard and 1859.2 for MDF, contain the specifications but do not include the testing methods.

The limits are presented in one of three ways:

- as a single-sample maximum value which is used to classify one sample
- as an average maximum value used to classify a production run
- as a 95% pass value used to classify a production run

The new AS/NZS standards use the 95% option, meaning that statistically 95% of the product must pass the given value.

Test Standards

The "Specification Standards" refer to "Test Standards", the latter dictating how to carry out the emission testing. Although there is some crossover, the "Test Standards" may be divided into three types of method:

1) Reference Methods – The reference methods are designed to simulate a standard indoor environment and tightly specify all the relevant test variables. The use of reference methods is limited by their expense and by the time they take to complete. EN717-1 is a reference standard which specifies methods for 40m^3, 1m^3 and 0.25 m^3 chambers.

2) Certification Methods There are a number of certification methods which are used for certifying product for sale. These methods are easier and cheaper to set up and run, but give reasonable correlations with the reference methods. The two methods commonly used in New Zealand are EN120, the toluene extraction method and JISA5905, the Japanese desiccator method.

3) Quality Control Methods – For in-house use, a number of quick methods have been developed. These methods allow production to be monitored regularly but are not normally used for certification of a product. In this category there are various flask methods using a plastic bottle as the test chamber. There are also a number of specialised devices such as the DMC (Dynamic Micro Chamber) and FLEC (Field and Laboratory Emission Cell) and these have the advantage of rapid analysis.

Converting Between Methods

Because the various economic trade regions use different test methods - research organisations, such as the WKI in Germany, have produced correlations between some of the methods. However the conversion factors differ for different products because factors such as density, density profile and thickness of the product effect the relationships. This is due to fundamental differences between the methodologies. For example, the EN120 test uses toluene extraction, whereas most other methods are based on measuring the actual formaldehyde emission from the sample. The toluene extraction gives good correlation with the reference methods at higher emission levels but gives poor correlation at low emission levels. There are also differences between the various “emission” based methods - including the size and shape of the sample, the ratio of exposed edge to face and the temperature and relative humidity at which the test is performed.

The Future

Although the Standards differ throughout the world, there is a trend towards standardisation within the major economic trading blocks. The Japanese, Australian and New Zealand (JANS) committee have recently carried out a review of panel product standards. During this process the JIS and AS/NZS Standards have been “harmonised” to further ease trade between Japan, Australia and New Zealand.

Table 1 Specification Standards and Classifications

Standard	Method	Product	Trading Area	Limit Terms	Classification	Value
JISA5905 2003	Japanese Desiccator	Fibreboard	Asia – Pacific	Average*1	F**** F*** F**	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3
JISA5908 2003	Japanese Desiccator	Particle Board	Asia – Pacific	Average*1	F**** F*** F**	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3
JAS988 2000*4 JAS989 2000*4	JAS 40 Litre Perspex Chamber	LVL Structural LVL	Asia – Pacific	Average*1	F**** F*** F** F*	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3 ≤5.0mg/L*3
JAS990 2000*4	JAS 40 Litre Perspex Chamber	Flooring	Asia – Pacific	Average*1	F**** F*** F** F*	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3 ≤5.0mg/L*3
JAS991 2000*4 JAS992 2000*4	JAS 40 Litre Perspex Chamber	Glulam Structural Glulam	Asia – Pacific	Average*1	F**** F*** F** F*	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3 ≤5.0mg/L*3
JAS233 2003	Japanese Desiccator	Plywood	Asia – Pacific	Average*1	F**** F*** F** F*	≤0.3mg/L*3 ≤0.5mg/L*3 ≤1.5mg/L*3 ≤5.0mg/L*3
AS/NZS 1859.1 2004	Japanese Desiccator	Particle Board	AS/NZS	95%	E1 E2	≤1.8mg/L ≤5.4mg/L
AS/NZS 1859.1 2004	Perforator	Particle Board	AS/NZS	95%	E1 E2	≤10mg/100g ≤30mg/100g
AS/NZS 1859.2 2004	Japanese Desiccator	Fibreboard	AS/NZS	95%	E1 E2	≤1.1mg/L ≤3.3mg/L
AS/NZS 1859.2 2004	Perforator	Fibreboard	AS/NZS	95%	E1 E2	≤10mg/100g ≤30mg/100g
EN 312-1 1996	Perforator	Particle Board	Europe *2	Average*1	1 2	≤8mg/100g ≤30mg/100g
EN 622-1 1997	Perforator	Fibreboard	Europe *2	95% *1	A B	≤9mg/100g ≤40mg/100g

*1 Maximum values also given.
*2 Some countries within the Europe have different requirements. Refer to the current standard.
*3 These values are mean values for a certain number of samples for a production run. Maximum values are also given. At time of printing, some values still to be confirmed.
*4 These standards are in the process of re-issue, possibly under new numbers.

Table 2 – Test Standards and Products

Method	Standards	Products	Trading Area	Usage	Summary
Chamber	EN717-1 ASTM E1333	All	World Wide	Reference Research Certification	Samples are placed in a constant humidity chamber. Air is continuously replaced. The test is complete once constant emission is reached - this may take several weeks.
Japanese Desiccator	JIS A 1460 JIS A 1460 JAS 233 AS/NZS 4266.16	Fibreboard Particleboard Plywood Fibreboard and Particleboard	Asia AS/NZS	Certification Q.C.	Samples are placed in a glass desiccator for 24 hours at 20ºC. The RH is uncontrolled. Formaldehyde is collected in water. The concentration is measured by a chemical reaction followed by spectrophotometry.
American Desiccator	ASTM D 5582	Wood products	USA	Certification Q.C.	Samples are edge sealed and placed in a glass desiccator for 2 hours at 24ºC. The RH is uncontrolled. Formaldehyde is collected in water.
JAS 40 Litre Perspex Chamber	JAS 988 JAS 989 JAS 990 JAS 991 JAS 992	LVL Structural LVL Flooring Glulam Structural Glulam	Asia AS/NZS	Certification Q.C.	Samples are placed in a 40 litre perspex desiccator for 24 hours at 20ºC. The RH is uncontrolled. Formaldehyde is collected in water. The concentration is measured by a chemical reaction followed by spectrophotometry.
Perforator	EN120	Fibreboard Particleboard	Europe AS/NZS	Certification Q.C.	110 gram of sample is extracted using toluene. Formaldehyde is transferred to water. The concentration is measured by a chemical reaction followed by spectrophotometry.
AWPA Flask	AWPA Method	Fibreboard Particleboard	Australia	Q.C.	About 20gram of sample is placed in a plastic bottle. Test is carried out at 40ºC for 24 hours. Formaldehyde is collected in water. The concentration is measured by a chemical reaction followed by spectrophotometry.
EN Flask	EN717-3	Fibreboard Particleboard	Europe	Q.C.	About 20 gram of sample is placed in a plastic bottle (of different dimensions to the AWPA flask) Test is carried out at 40ºC for 3 hours. Formaldehyde is collected in water. The concentration is measured by a chemical reaction followed by spectrophotometry.

Table 3. Approximate Conversion Factors For Particle Board and MDF. MDF Values Are Given In Brackets.

MDF values are given in brackets.	Chamber EN717-1 (mg/m3)	Japanese Desiccator JISA1460 etc (mg/L)	Perforator EN120 (mg/100g o.d.)	American Desiccator STM55 (mg/mL)	Flask EN717-3 (mg/kg o.d.)	Flask AWPA Method (mg/100g o.d.)	FLEC (mg/m² x hr)
Chamber EN717-1	1		60 *4				1.14 *6
Japanese Desiccator JISA1460 etc		1	4.5 *2 (9.0 *2)		6.7 *3 (6.0*3)	8.8 *3 (7.7*3)	
Perforator EN-120	0.017 *4	0.22 *2 (0.11 *2)	1	0.06 *1			
American Desiccator ASTM5582			16 *1	1			
Flask EN 717-3		0.15 *3 (0.16 *3)			1	1.3 *3	
Flask AWPA Method		0.11 *3 (0.13 *3)			0.76 *3	1	
FLEC	0.88*6						1

*1 Comparative Response of Reconstituted Wood Products to European and North American Test Methods for Determining Formaldehyde Emissions. Environmental Science and Technology, Vol 25, No 1, 1991.

*2 Stephen Young and Associates Ltd, Unpublished Data, 1999-2000.

*3 Stephen Young and Associates Ltd LabCheck – TILTS inter-laboratory trials, 1999-2000 (limited data).

*4 Meyer, B. Determination of the Correlation for E1 Particleboards Using the 1m³ and the Perforator Method, WKI Short Report No 11/1996. (Values given are approximations from the report)

*5 Meyer, B. Determination of the Correlation for E1 Particleboards using the 1m³ Chamber and the Flask Method, WKI Short Report No 13/1996.

*6 Risholm, M. Determination of Formaldehyde Emission with Field and Laboratory Emission Cell (FLEC). Indoor Air 1999:9 268-272.