Emission from wood-based products

March 2005

Summary

Consumers in the developed countries are becoming increasingly concerned about the safety of the products they use. Japan in particular is leading the way to lowering formaldehyde emission limits for wood-based products used within buildings. For these products ISO Guide 65 certification is becoming a requirement for trade with Japan.

Background

Sick-house Syndrome Spreads To Schools: Kyodo News; October 2003

"Sick-house syndrome (a skin and respiratory ailment that is linked to chemical pollutants in enclosed areas) appears no longer confined to residential houses. Education officials in Japan have detected air pollutants linked to sick-house syndrome in many education facilities, causing headache and nose and throat irritation among students."

Introduction

In the past four years there have been a number of news headlines in Japan associated with Sick House Syndrome. While the scientists and health professionals may still be debating the true dangers presented by this issue, the public and authorities have made their decisions and the regulatory process has already taken place. For those of us involved with formaldehyde emission from wood products the headlines have been just the tip of the iceberg. Behind the scenes there has been a growing labyrinth of new regulations necessitating development of advanced adhesive, manufacturing and testing technologies and also quality certification systems for the finished product.

The trend to control formaldehyde-emitting products has had a growing affect on the wood products industry in New Zealand. Panel products, (MDF, particleboard and plywood) and engineered wood products, (Laminated Veneer Lumber and Glued Laminated Lumber) often use formaldehyde based adhesives and therefore continuously emit small, decreasing amounts of formaldehyde gas into the atmosphere. There are two options for reducing the formaldehyde emission from these types of product. The first is to move to non-formaldehyde adhesives, but these are normally more expensive and there are other health issues associated with some of these chemicals. The second widely adopted option has been to develop the formaldehyde resins technologies to enable production of products that comply with the new low emission requirement.

Over the past seven years TimberTest has been a leader in the technologies associated with formaldehyde emission testing of wood based products. In the last three years TimberTest has also been active in the submission process involved with the regulatory changes resulting from sick buildings in Japan and Korea. In these countries it was found that the gases given off by the building materials, insulation, furniture and fittings were causing flu like symptoms in people living in some buildings. Whilst many of the pollutants found in these modern buildings may not have caused problems in the past, the air tightness of some modern buildings was found to be leading to a build up in pollutants. Since the beginning of the official reaction to the issue there has been a stream of regulation changes in Japan. Firstly the various testing standards and specifications were updated, followed by legislation to control the distribution and use of the products. Finally the most recent notifications have regarded a shift to the ISO Guide 65 product certification standard to bring the new regulations into line with World Trade Organisation recommendations.

For the manufacturing exporters and resin suppliers these changes have provided a number of challenges. The new technologies developed for the Japanese markets will provide opportunities in other regions where there are also lowering formaldehyde emission limits. For TimberTest these changes have meant constant development and change with ongoing investments in equipment and systems to provide the service needed by the manufacturing exporters.

Sick House Countermeasures in Japan

After reports that some buildings were making people sick and measurements of gases in the indoor air indicated that the concentration of pollutants in some buildings in Japan were above the World Health Organisation recommendations, the "Sick House Countermeasures" (1) were instigated to combat the problem. Whilst other volatile organic compounds (VOC's) have also been included in the specifications, the initial regulatory reaction has focussed mainly on formaldehyde. Formaldehyde produces a number of a skin and respiratory ailments and is also classed as a carcinogen by the International Agency for Research on Cancer(2). The Japanese sick house countermeasures include recommendations, laws and regulations falling into a number of categories, i.e. indoor air guidelines, emission classifications, building regulations, testing standards and the JIS/JAS-mark quality control for product sold in Japan.

Japanese Ministry of Health, Labour and Welfare Guidelines for Indoor Air Quality

The primary reference for indoor air quality is the World Health Organisation (WHO) recommendations on indoor air quality. These documents provide maximum recommended levels of pollutants in indoor air. Based on the WHO recommendations the Japanese Ministry of Health, Labor and Welfare has produced guidelines covering a range of VOC's including formaldehyde(3). This guide recommends the maximum formaldehyde in indoor air should be less than 100µg/m^3. In New Zealand, the Ministry for the Environment has recently produced a similar document(4).

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Standards Specifying Emission Classifications

The reference studies for categorisation of products into "classes" are carried using standard test chambers with a fixed ratio of the formaldehyde emitting material to chamber volume and with controlled air exchange rates.

In Japan these classifications exist in each of the many standards that cover the wide range of wood based building products. For example MDF, Particleboard, Plywood, Glulam and LVL all have their own standards [5,6,7,8]. However in conjunction with the sick house countermeasures, the terminology and emission classes used in the standards have been harmonised. These harmonised classes are identified using star ratings, from two star to four star, the lower the emission the more stars (F**, F*** and F****).

The high level of formaldehyde found in Japanese buildings was not predicted because formaldehyde emitting products were controlled under the existing law. However investigation revealed that some Japanese buildings were hotter, more humid and had fewer air exchanges than the "standard conditions" assumed for the predictions of emission. Since formaldehyde emission from wood based products is higher in such hot, humid conditions the emission was tested in the conditions actually found within the buildings. This process led to the introduction of a new very low emission category, initially termed Super E0, and now known in harmonised terminology as F****.

Introduction of the F**** class has created both challenges and market opportunities for New Zealand manufacturers. There was little experience world wide with producing formaldehyde based resin products at such low emission levels. In Germany for example, another country sensitive to indoor air quality issues, the limit is more than twice the F**** value. The requirement for low emission products has put pressure on the New Zealand manufacturing exporters, on the resin manufacturers to develop a new range of ultra low emitting resins and on laboratories like TimberTest to provide the accurate testing required for development and export certification.

Japanese Amended Building Standard Law

The regulations regarding the use of product to be used within buildings are contained in the Building Standard Law [1]. This document specifies the amount of F*** and F** which may be used within a room depending on air exchange and room size and is related to a co-efficient factor given in Table 1. F**** is unrestricted and this has resulted in a very large demand for F**** product.

JIS/JAS-mark Quality Systems

Manufacturers of formaldehyde emitting construction materials for use within buildings in Japan must have proof that their manufacturing systems are suitable. For most companies this means accrediting their plants to the JIS or JAS-mark. These are quality management systems similar to ISO9002 except audits may only be conducted by certifying bodies accredited by the Japanese authorities. The audits are conducted by "Registered Certification Bodies" such as AWPA in Australia.

For Particleboard and MDF which are regulated under the Japanese Industry Standards (JIS), the JIS-mark is not presently compulsory, there is an alternative "Ministerial Approval" process which allows for product certification by authorised Japan based laboratories. For construction materials covered by Japanese Agricultural Standards (JAS), such as Plywood, LVL and Glulam, the JAS-mark is compulsory.

It is possible to manufacture in a factory without the JIS/JAS-mark accreditation and "mark" the product during a later process. For example, a non-JIS/JAS-mark manufacturer in New Zealand can export to Japan where the product is further processed by a factory with the JIS/JAS-mark accreditation.

Table 1. Co-efficient for calculation of the amount of each emission class allowed in a room.

Type of Room	Ventilation	Coefficient for area of use calculation			
		F****	F***	F**	F*
Home	Over 0.7	No limitation	0.2	1.2	Prohibited
	0.5 – 0.7	No limitation	0.5	2.8	Prohibited
Office	over. 0.7	No limitation	0.15	0.88	Prohibited
	0.5 – 0.7	No limitation	0.25	1.4	Prohibited
	0.3 – 0.5	No limitation	0.5	3.0	Prohibited

For full details see [*1] *Japan Amended Building Standard Law on Sick House Issues July 12, 2002.*

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Laboratory Testing

A cornerstone of this maze of regulations is the testing laboratory, which receives representative samples and determines the classification for a shipment or run of the product. The emission testing of product exported to Japan has been particularly problematic. Some of the problems are typical of the testing of many other products. For example every trade region uses different testing methods and for technical reasons it has been hard to produce accurate conversion factors to benchmark the new specifications in Japan against those of other regions. One of the early projects conducted by TimberTest was to produce these conversion factors allowing New Zealand companies to rank their products in other world markets.

The second issue has been that the testing standard specified for products exported to Japan, known as the "Japanese Desiccator Test" had been written when emission levels were up to ten times the level of the new specifications. When TimberTest first started carrying out formaldehyde emission it was apparent that New Zealand products were not receiving the same emission rating from all laboratories. TimberTest instigated a number of round robin trials with other laboratories and these indicated that different laboratories gave quite different results. In fact different laboratories testing the same product gave results spanning from the lowest to the highest emission class. There were also problems with repeatability, in that when one laboratory tested the same product on several occasions they could rate the product as a different emission class each time they tested it. These problems were not just confined to production laboratories, but included government and private research laboratories. This was obviously creating some major headaches for both the producers and the resin developers since identical products could obtain different emission ratings depending on when and where they were tested. Of particular concern were situations where the seller and buyer of products exported from New Zealand could not agree on the emission classification of products. In addition the fact that laboratories could not agree made the whole classification system questionable.

To investigate this problem visits were arranged to testing laboratories around Asia-Pacific to establish how the emission testing was being conducted. The differences between the methodologies being used were simulated in the TimberTest laboratory to determine which of the factors were causing the differences in test results. This work was then published to stimulate discussion and reach agreement on how the testing should be conducted(9). At this time there was also the "Joint Japan Australia and New Zealand Standards Harmonisation Committee" producing joint test methods called "JANS". During this process the Japanese, Australian/New Zealand standards were harmonised to produce a common set of methods with the objective of reducing trade barriers between these countries. Based on the TimberTest studies, TimberTest produced a new JANS formaldehyde emission testing standard. This harmonised method was then adopted by both JIS (Japanese Industry Standards) and AS/NZS standards.

TimberTest has also continued to run the round robin (LabCheck inter-laboratory trials) as a commercial service, with many laboratories around the world now taking part. Gradually the difference between the emission results from different laboratories has reduced. Additionally TimberTest and two other laboratories worldwide now have International Accreditation (IA) [*10] incorporating the Japanese emission test. The three IA laboratories have good reproducability, with all three rating products into the same emission class.

ISO Guide 65 Certification and ISO 17025 Laboratory Standards

During the introduction of the new regulations in Japan there has been opportunity via our Japanese Embassy to make submissions on the process. Government agencies and New Zealand companies including TimberTest put forward requests that JIS-mark and quality management of the laboratory testing should be by ISO standards to allow easier integration with the quality management systems already in place.

In June this year a new law was passed in Japan to amend the JIS-Mark Scheme, under this new law the Government Ministry METI will not run the certification of products, instead it will be done by Registered Certification Bodies (RCB's). All present RCB's must re-apply for registration. The RCB must comply with ISO Guide 65 and testing must be done in a laboratory complying with ISO Guide 65. Under the new system importers and sellers within Japan and companies further processing into finished products may apply for certification.

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Japanese VOC Regulations

At present the only limits for other VOC's are the air limits for School buildings. The school-air limits have been set by the Ministry of Education and indirectly affect suppliers of School furniture and fittings. While these limits are similar to guidelines from other countries, the lower air exchange rates and higher humidity and temperatures assumed for the regression to the product specifications may lead to very tight VOC regulations for products used within buildings – similar to the tight F**** formaldehyde specification.

The standard for measuring VOC's from building products is JIS A 1901 which is a cylindrical chamber method prescribing humidity temperature and exchange rates in a similar manner to EN717-1. This method also gives target values for indoor air as specified by the Ministry of Health Labor and Welfare (Table 2). It is not a legal requirement to comply with these target values except for within School buildings where these values have been adopted by the Ministry of Education. Additionally it is expected by many exporters to Japan, that these values will form the basis for emission regulations for indoor spaces in 2005 and in turn will be used in the calculation of VOC emission specifications for material.

Trends in Japan

In Japan there is a high level of public awareness of both formaldehyde and VOC's in general. Manufacturers may choose from a number of systems to label products as low VOC or F**** even if they are not required to do so by law. It is expected that there will be a move to introduce a VOC regulation for a range of products in 2005 and it is also expected that furniture and other products not covered by regulation now will be regulated with the same requirements as the building products.

Trends in New Zealand and Australia

The MDF and Particleboard limits in New Zealand and Australia are specified in joint AS/NZS Standards. At present these standards prescribe the emission limits as both perforator values (EN120) or Japanese Desiccator values (Table 3), however the perforator option is to be removed since it is no longer used in the home markets. Plywood standards are in draft at present and will be based on a version of the Japanese Desiccator method. Until now the limits have been similar to the European classification, however in August this year (2004), based on public awareness of the availability of low emission products for the Japanese markets it was decided that a new lower emission classification would be introduced in 2005, this is at the same level as the Japanese F***. The new limits will not apply to Particleboard flooring. There are no moves at present to introduce an equivalent to F**** rating. At present there is little public awareness or concern for emission of VOC's in either country and no intention to introduce VOC requirements.

Table 2. Examples of Target Air Contamination Chemicals (Japanese Ministry of Health Labor and Welfare)

Chemical	Guideline Value ($\mu g/m^3$)
Toluene	260
Xylene	870
p-dichlorobenzene	240
Formaldehyde	100
Acetaldehyde	48

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Table 3. AS/NZS Particleboard and Fibreboard Formaldehyde Limits and Standards

Specification Standard	Test Standard	Classification E2	E1	E0 (2005)
AS/NZS 1859.1 Particleboard	Japanese Desiccator AS/NZS 42566:16:2004 (mg/L)	>1.5 ≤5.4	≤1.5	≤0.5
	Perforator EN120 (mg/100g o.d.)	>8 ≤30	≤8.0	Not given
AS/NZS 1859.2 Fibreboard	Japanese Desiccator AS/NZS 42566:16:2004 (mg/L)	>1.0 ≤3.3	≤1.0	≤0.5
	Perforator EN120 (mg/100g o.d.)	>9 ≤30	≤9.0	Not given
AS/NZS 1860.1 Particleboard Flooring	Japanese Desiccator AS/NZS 42566:16:2004 (mg/L)	>1.8 ≤5.4	≤1.8	
	Perforator EN120 (mg/100g o.d.)	>10 ≤ 30	≤10	

Limits are based on 95 % pass rates. E0 for introduction in 2005.

JAS-ANZ

JAS-ANZ is the "Joint Accreditation System of Australia and New Zealand ". This is a bilateral agreement between the two countries. The JAS-ANZ mission is to ensure the JAS-ANZ accreditation process enhances trade between New Zealand and Australia and achieves international recognition of the excellence of Australian and New Zealand goods and services. This system includes product certification based on ISO Guide 65 for wood based products. The Australian Wood Panels Association (AWPA) operates certification for MDF and Particleboard and the Plywood Association of Australasia (PAA) certifies engineered products such as Glu-lam, LVL and plywood. Presently this is voluntary system, however it has been widely adopted by the Australian markets and is expected to be phased into New Zealand shortly.

Trends in Other Regions Around Asia

Hong Kong has a voluntary green label system run by the Green Council giving low VOC and formaldehyde limits for products such as flooring materials. In both China and Hong Kong there are legal specifications with E1 and E2 limits based on the perforator method and Desiccator method and there is a move to reduce all products used within homes to the lower E1 value (Table 4).

Most other countries in Asia do not have regulations governing indoor air or emission from materials. Singapore and Malaysia for example do not have regulations. However the Japanese market is very important for all the Asian countries and therefor many manufactures are affected by the Japanese trends and much of the production is aimed at the low emission markets. Material sold to Asian countries will often be manufactured into product sold to Japan and for this reason companies in these other countries with high or no limits may still order low emission products based on Japanese test methods

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Table 4. China Particleboard and Fibreboard Formaldehyde Standards and Limits

Material	Method	Classification	
		E2	**E1**
Particleboard and Fibreboard	Perforator EN120 (mg/100g o.d.)	≤30	≤9
Plywood	Desiccator GB18580-200 (mg/L)	5	1.5

The perforator values are not corrected to 6.5% moisture content.

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Conclusions

The trend in the developed world is to an ever-increasing expectation that the products we use are safe for the general population and also for sensitive individuals. The definition of "safe" is a continuously moving target, creating niche opportunities for fast reacting companies.

There are trends towards harmonisation occurring within each of the trading blocks. The EU forms one trading region with agreement on testing methodology and CE marking. Japan is the major country influencing emission trends within the Asia-Pacific region. There is a widespread move to use Japanese testing standards, not only by Australia and New Zealand but also in other Asian countries. At present JIS products may be used in Japan with "Ministerial Approval" however it is expected that in the future all companies exporting formaldehyde emitting JIS or JAS construction products for use within buildings in Japan must JIS/JAS-mark their products.

Over the next two years the JIS/JAS-mark process will change with IA laboratory testing being introduced and a transition from Japanese ministerial law to ISO Guide 65. These changes are indicative of world trends to reduced trade barriers in accordance with the World Trade Organisation guidelines. As yet there are no laboratories in Japan with International Accreditation covering formaldehyde emission from wood based products. However given the current world trends Japan will almost certainly have such a facility within a few years. Once Internationally Accredited laboratories are used throughout the world the audit, peer review and Inter-laboratory comparison processes will help reduce the problems associated with differences between laboratories.

Internationally Accredited laboratories are becoming increasingly important for the trade in low emission products. These laboratories will soon be required to certify product for sale to Japan and are being increasingly used to assure the quality of products during the sale process.

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Table 5 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
SE-10 2003	JAS 40 Litre Perspex Chamber	LVL	Asia – Pacific	Average*1	F**** F*** F** F*	0.3mg/L*3 0.5mg/L*3 1.5mg/L*3 3.0mg/L*3
SE - 7 2003	Japanese Desiccator	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
SE - 9 2003	JAS 40 Litre Perspex Chamber	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
JAS232 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.

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Table 6 – 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 232 AS/NZS 4266:16 JAS SE - 7	Fibreboard Particleboard Plywood FB and PB Flooring	Asia Australia New Zealand	Certification Q.C.	About 1800 cm^2 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 SE - 10 JAS SE - 9	LVL Structural Glulam	Asia Australia New Zealand	Certification Q.C.	450 cm^2 samples are end-sealed and 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 Australia New Zealand	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.

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Table 7. 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/m^2 x hr)
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

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