Producing Panels with Formaldehyde Emission at Wood Level

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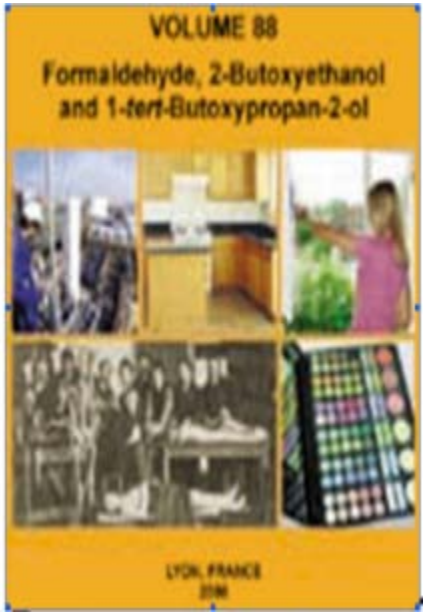
Structure of the presentation

- The formaldehyde debate
- Occupational exposure limits
- Formaldehyde test methods
- Emission standards for wood based panels
- Industrial application of Chimar Technology
- Summary / Conclusions

Re–evaluation of formaldehyde

- IARC (WHO) meeting, France, June 2004: formaldehyde is “carcinogenic to humans (Group 1)” vs previous evaluation as probably carcinogenic to humans (Group 2A)
- Immediate reactions & concern by industry and associations: CPA & FCI (N. America), EPF & FormaCare (Europe)
- Concerns by regulatory authorities, “green” organisations, worker and consumer associations
- IARC decision based on studies regarding exposure 30-60 years ago, while workplace levels have declined dramatically the past three decades (CPA & FCI 2004). IARC classification is a “hazard identification” not full risk assessment (FCI & EPF 2004)
- New toxicological & cancer studies were initiated since 2005 in Europe and USA

IARC Monographs Vol 88, Dec 2006



- **Report** on the evaluation of carcinogenic risk to humans posed by a selected chemical
- The highest occupational exposure in varnishing, production of textiles, garments, furs, certain jobs in board mills and foundries
- Lower exposure levels in formaldehyde production (mean concentration < 1ppm). Wide range of exposure levels in resins production – all data from the 1980s

In wood products manufacture, exposure occurs during glue mix preparation, laying of mat, hot pressing and sanding – all data from the 1960s-70s-80s – mean concentrations > 1ppm in PB, ~2ppm in PW, however, recent studies reported concentrations lower than 0.4ppm in PW, and less than 0.16ppm in OSB & MDF

Current Status

- **EU** current formaldehyde classification: **category 3-R40** "limited evidence of a carcinogenic effect". It will be reviewed under REACH regulation using the results of new studies.
- **US** EPA current classification: **probable human carcinogen (B1). However, draft toxicological review of formaldehyde-inhalation assessment** released **June 2010.**
- **IARC** monograph (December 2006): There is sufficient evidence in humans & experimental animals for the carcinogenity of formaldehyde – **Group 1. Reaffirmed October 2009.**
- **CARB** formaldehyde emission limits for composite wood products are in force since **January 2009** and should apply throughout the US from **January 2013**.

Operational Exposure Limits (1/3)

Country	Concentration, ppm	Type
Australia	1.0	TWA
Austria	0.3	TWA
Belgium	0.3	Ceiling
Brazil	1.6	Ceiling
Canada-Alberta	0.75	TWA
Canada-British Columbia	0.3	TWA
Denmark	0.3	TWA & STEL
Finland	0.3	TWA
France	0.5	TWA

Source: Formacare. IARC

Operational Exposure Limits (2/3)

Country	Concentration, ppm	Type
Germany	0.3	TWA
Greece	2.0	TWA
Hong Kong	0.3	Ceiling
Ireland	2.0	TWA
Italy	0.3	Ceiling
Japan	0.5	TWA
Malaysia	0.3	Ceiling
Mexico	2.0	Ceiling
Netherlands	1.0	TWA
New Zealand	1.0	Ceiling

Source: Formacare. IARC

Operational Exposure Limits (3/3)

Country	Concentration, ppm	Type
Norway	0.5	TWA
South Africa	2.0	TWA
Spain	0.3	STEL
Sweden	0.5	TWA
Switzerland	0.3	TWA
United Kingdom	2.0	TWA
USA-ACGIH	0.3	Ceiling
USA-NIOSH	0.016	TWA
USA-OSHA	0.75	TWA

Source: Formacare. IARC

Formaldehyde Test Methods

Test Method	Standard, standard draft or method name
Chamber	EN 717-1, ASTM E 1333, ASTM D 6007, JIS A 1901, JIS A 1911, ISO 12460-1, ISO 12460-2
Gas Analysis	EN 717-2, ISO 12460-3
Flask Method	EN 717-3, AWPA method
Desiccator	ASTM D 5582, JIS A 1460, JAS 235, JAS 233, AS/NZS 4266.16, ISO 12640-4
Perforator	EN 120, ISO 12460-5
Other	Field and Laboratory Emissions Cell (FLEC), Dynamic Micro Chamber (DMC)

European Standards

Board class	HCHO limit	Test method
E1 - PB, MDF, OSB	Release ≤ 0,124 mg/m^3air ≤ 8.0mg/100g	EN 717-1 EN 120
E1 - PW	Release ≤ 0,124 mg/m^3 air ≤ 3.5mg/h*m^2	EN 717-1 EN 717-2
E2 - PB, MDF, OSB	Release > 0,124 mg/m^3 air >8.0 ÷ ≤30mg/100g	EN 717-1 EN 120
E2 - PW	Release > 0,124 mg/m^3 air > 3.5 ÷≤ 8.0mg/h*m^2	EN 717-1 EN 717-2

Source: EN 13986

NOTE: E1 rolling average for half year <6.5mg/100g PB/OSB, <7mg/100g MDF

EPF - S

- Industry standard prepared by EPF and applied to its members
- Establishes a new class of low formaldehyde emitting panels: EPF-S
- Based on perforator (EN120) limit values for particleboard 4mg/100g and MDF 5mg/100g (thickness > 8mm)
- Revised to include equivalent limit values based on EN 717-1 (chamber method)

Japanese Standards

Board class	HCHO limit	Test method
F****/SE0	≤ 0.3mg/L	JIS A 1460
F***/E0	≤ 0.5mg/L	JIS A 1460
F**	≤ 1.5mg/L	JIS A 1460

Source: JIS A 5908 & 5905

F** class in Japan is more or less equivalent to European E1-class
F*** and F**** are of much lower emission than the E1
F**** emission is close to the emission of solid untreated wood

AS/NZ Standards

Board class	HCHO limit	Test method
E0 - PB, MDF	≤ 0.5mg/L	AS/NZS 4266.16
E1 - PB	≤ 1.5mg/L	AS/NZS 4266.16
E1 - MDF	≤ 1.0mg/L	AS/NZS 4266.16
E2 - PB, MDF	≤ 4.5mg/L	AS/NZS 4266.16

CARB Standards

Effective Date	Phase 1 (P1) & Phase 2 (P2) Emissions Standards				
	HWPW-VC	HWPW-CC	PB	MDF	Thin MDF
01.01.2009	P1:0.08	-	P1:0.18	P1:0.21	P1:0.21
01.07.2009	-	P1:0.08	-	-	-
01.01.2010	P2:0.05	-	-	-	-
01.01.2011	-	-	P2:0.09	P2:0.11	-
01.01.2012	-	-	-	-	P2:0.13
01.07.2012	-	P2:0.05	-	-	-

Formaldehyde Emission Standards for Hardwood Plywood (HWPW), Particleboard (PB) and Medium Density Fiberboard (MDF), CARB 2008
Based on the primary test method [ASTM E 1333-96 (2002)] in ppm
HWPW-VC: veneer core, HWPW-CC: composite core
Source: CARB 2008, NOTE: Same as ANSI A208.1&2 for PB and MDF

CARB vs. European & Japanese Standards

P1 (ppm)	**E1**	**F*****	**F******
HWPW (0.08)	More	Comparable	Less
PB (0.18)	Less	Less	Less
MDF (0.21)	Less	Less	Less
P2 (ppm)	E1	F***	F****
HWPW (0.05)	More	More	Comparable
PB (0.09)	More	Comparable	Less
MDF (0.11)	Comparable	Less	Less

Values in parenthesis are the Phase 1 or Phase 2 standards in ppm.
"More" means the proposed standard is "more stringent" than applicable E1, F***, F**** standards.
Source: CARB 2008

CARB ULEF provisions

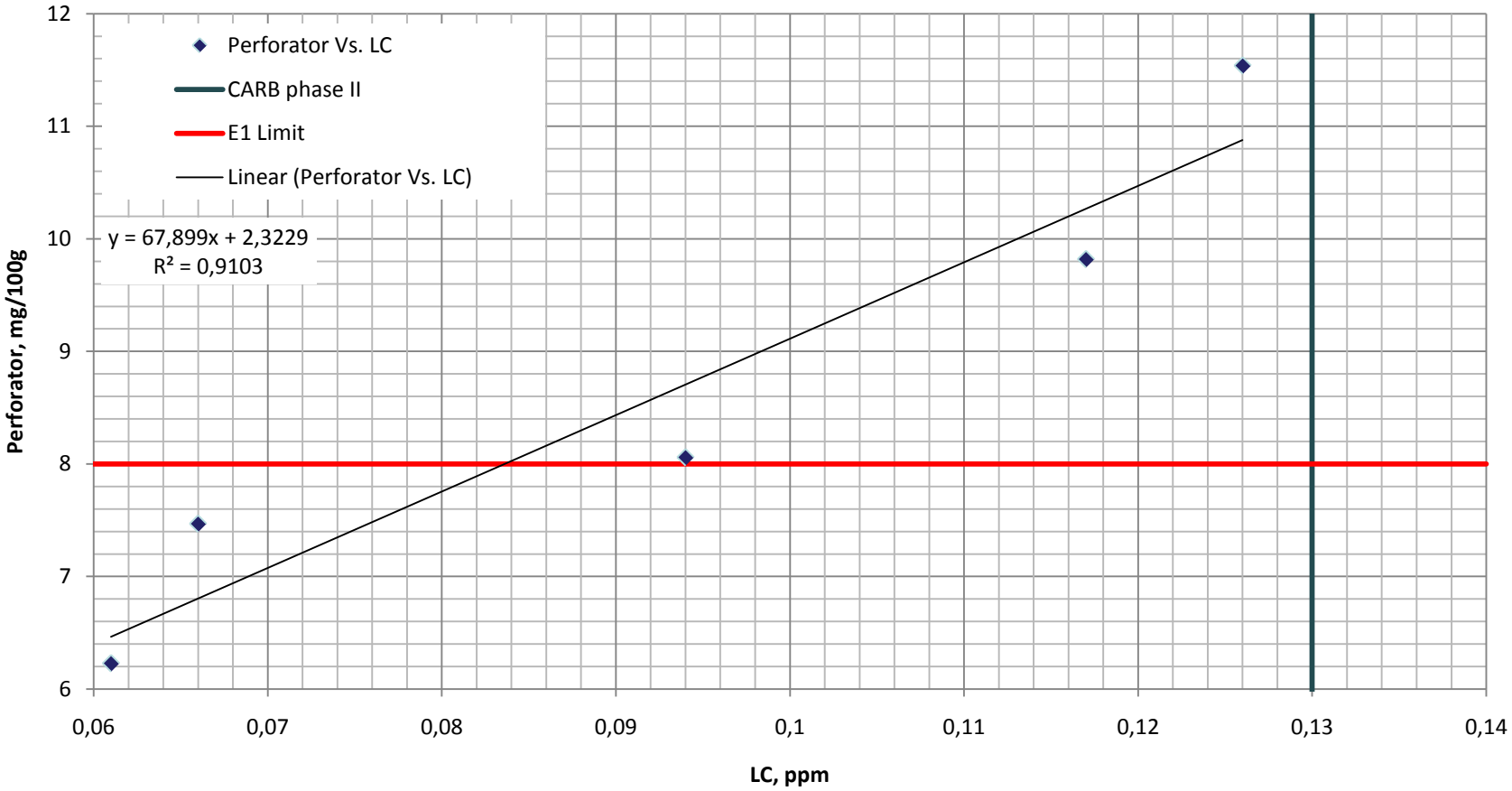
- “Ultra-Low-Emitting Formaldehyde (**ULEF**) resins”: average formaldehyde emissions consistently below the Phase 2 emission standards
- Less frequent emission tests of the products than otherwise required
- Possible qualification for an exemption from third party certification
- Labelling of the products as made using ULEF

ULEF Emission Target and Cap Values

Less frequent testing	PB	MDF	Thin MDF	HWPW
ULEF-target	0.05	0.06	0.08	0.05
ULEF-cap	0.08	0.09	0.11	0.05
TPC exemption	**PB**	**MDF**	**Thin MDF**	**HWPW**
ULEF-target	0.04	0.04	0.04	0.04
ULEF-cap	0.06	0.06	0.06	0.05

Values in ppm.
Source: CARB 2008

Thin MDF: CARB P2 vs. E1



All samples are CARB P2 but not E1!

LC values obtained through DMC and certified correlation

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Formaldehyde emission reduction by CHIMAR HELLAS

- **High Performance gluing systems:**
- Innovative **resin** and **additive** formulations
- Produced from controlled raw materials
- Best exploitation of the active ingredients during resin synthesis aiming no loss in productivity and minimal cost increase
- Efficient monitoring and control of the synthesis parameters

Data from “E0” MDF

“E0” MDF (14 mm), UMF + FS	
Press Factor, s/mm	As E1
Resin Factor, %	20% higher than E1
Board Density, kg/m^3	690-710
Board thickness, mm	14.0-14.3
IB, N/mm^2	0.6-0.7
Formaldehyde content, EN 120, mg/100g dry board	2.5-3.0
Cost Vs E1 € per m^3	**+9**

Data from F***/E0 MDF

F***/E0 MDF (6 & 16mm), UF		
	6mm	16mm
Press temperature, ^{o}C	180-190	180-190
Press Factor, s/mm	As in E1	
Resin Factor, %	8.3	10.5
Board Density, kg/m^3	790-810	680-700
IB, N/mm^2	1.33 – 1.50	0.90 – 0.95
MOR, N/mm^2	40-42	30-35
Thickness swell, %	18-20	7-8
Formaldehyde emission, JIS A 1460, mg/L	0.3-0.5	
Cost Vs E1 € per m^3	**0**	

Data from F***/E0 MR MDF

F***/E0 MR MDF (18mm), UMF	
Press temperature, ^{o}C	190
Press Factor, s/mm	As E1
Resin Factor, %	13
Board Density, kg/m^3	700-720
IB, N/mm^2	1.0-1.2
Thickness swell, %	5.1-5.8
MOR, N/mm^2	37-40
MOR-A, N/mm^2 (2h $70^{o}C$)	4.9-5.3
IB after cyclic test, N/mm^2	0.2-0.4
TS after cyclic test, %	5-7
Formaldehyde emission, JIS A 1460, mg/L	0.27-0.39
Cost Vs E1 MR € per m^3	**+9**

Data from F***/E0 MR thin MDF

F***/E0 MR MDF (4mm), MUF + FS	
Press Factor, s/mm	As E1
Resin Factor, %	18
Scavenger level, %	15
Board Density, kg/m^3	795-832
IB, N/mm^2	1.30-1.89
Thickness swell, %	4.2-9.1
Formaldehyde emission, JIS A 1460, mg/L	0.31-0.45
Cost Vs E1 MR € per m^3	**+9**

Data from F****/“SE0” MDF

F****/“SE0” MDF (16mm), UMF + FS	
Press Factor, s/mm	As E1
Resin Factor, %	16
Scavenger level, %	15, 20
IB, N/mm^2	0.9-1.1
Thickness swell, %	7.0-7.4
Formaldehyde emission, JIS A 1460, mg/L	0.27-0.29
Cost Vs E1 € per m^3	**+12**

Data from F****/“SE0” thin MDF

F****/“SE0” MDF (3mm), UMF	
Press temperature, ^{o}C	180-190
Press Factor, s/mm	As E1
Resin Factor, %	14
Hardener level, %	0-1.5
Board Density, kg/m^3	840-860
IB, N/mm^2	1.6-1.8
MOR, N/mm^2	50-60
Thickness swell, %	16-21
Formaldehyde emission, JIS A 1460, mg/L	0.26-0.28
Cost Vs E1 € per m^3	**+9**

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Data from ULEF thin MDF

ULEF MDF (3mm), UF + FS	
Press Factor, s/mm	As CARB P1
Resin Factor, %	8
Scavenger level, %	20
Board Density, kg/m^3	880-930
IB, N/mm^2	1.6-1.8
MOR, N/mm^2	42-50
Formaldehyde emission, ASTM E 1333, ppm	0.03-0.04
Cost Vs CARB P1 € per m^3	**+3**

Data from F***/E0 PB

F***/E0 PB (16mm), UMF	
Press temperature, ^{o}C	210
Press Factor, s/mm	As E1
Resin Factor, %core/surface	8.5 / 9.5
Board Density, kg/m^3	630
IB, N/mm^2	0.42
MOR, N/mm^2	16.3
Thickness swell, %	12.1
Formaldehyde emission, JIS A 1460, mg/L	0.29
Cost Vs E1 € per m^3	**+5**

Data from F***/E0 MR PB

F***/E0 MR PB, MUF	
Press temperature, ^{o}C	210
Press Factor, s/mm	6.0
Resin Factor, %core/surface	8.5 / 9.5
Board Density, kg/m^3	642
IB, N/mm^2	0.61
Thickness swell, %	4.3
MOR, N/mm^2	18.2
MOR-A, N/mm^2 (2h $70^{o}C$)	6.4
Formaldehyde emission, JIS A 1460, mg/L	0.27
Cost Vs MR E1 € per m^3	**+3**

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Data from EPF-S PB

EPF-S PB (16mm), UMF	
Press temperature, ^{o}C	205
Press Factor, s/mm	As E1
Resin Factor, % core/surface	8.3 / 8.5
Board Density, kg/m^3	650-680
IB, N/mm^2	0.40-0.50
MOR, N/mm^2	13-14
Thickness swell, %	14-16
Formaldehyde content, EN 120, mg/100g	3.0-3.5
Cost Vs E1 € per m^3	**+2**

Data from ULEF PB

ULEF PB, UMF + FS	
Press Factor, s/mm	6.5
Resin Factor, % core/surface	8 / 10
Scavenger level, %	1.8-2.5
Board Density, kg/m^3	670-690
IB, N/mm^2	0.52-0.58
MOR, N/mm^2	15-18
Formaldehyde emission, ASTM E 1333, ppm	0.02-0.04
Cost Vs CARB P1 € per m^3	**+5**

Ensuring Cost Efficiency

To be able to produce cost efficiently boards with low emissions:

- Use of adhesives that are a result of intensive R&D
- Implement adequate process control in resin and board production
- Invest in new available technology

Summary

- Low emission MDF and PB (F***/E0, F****/”SE0”, EPF-S, ULEF) were produced using an advanced aminoplastic resin with or without scavenger.
- There was no need to change the production parameters or plant settings.
- There was **no loss** in productivity nor significant increase of production cost.
- The board properties were not adversely affected by the introduction of low emission resin system. In many cases there was even an improvement of board properties.
- The low emission quality can be achieved even in very specific cases such as the thin or moisture resistant panel products.

Conclusions

- Boards with low emissions are value added (higher quality) products.
- It is possible to meet the new demands for very low formaldehyde emission from composite panel products with the use of properly formulated **aminoplastic resin** systems, without any deterioration in panel performance or significant modification of plant operating conditions or need to employ other types of binders.
- The formaldehyde emission values that can be obtained are **at the level of natural wood.**

Final Remarks

- CHIMAR has reduced panel formaldehyde emissions by developing innovative resin systems, using advanced resin synthesis technologies and components that are well studied and controlled.
- Through its worldwide experience, network of customers and collaborating research institutes, CHIMAR develops and implements integrated solutions to the formaldehyde emission problem.
- CHIMAR research and development is ongoing and the publication of further positive data on low emission panels will follow.

Dedicated in the loving memory of:

c.PhD Dimitris Papapetros 1979 - 2009

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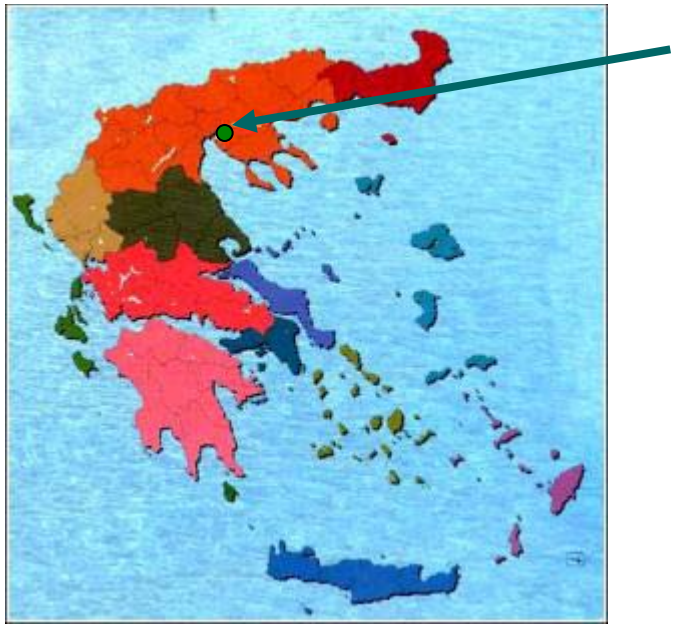

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Thank You!

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