Assessment of the Effect of the Applied Hydroxide Additives on the Fire Properties of Varnish Coating Systems with a Deafening Mass

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PN-EN 45545

Requirement set (used for)	Test method reference	Parameter and unit	Maximum or Minimum	HL1	HL2	HL3
R1 (IN1A; IN1B; IN1D; IN1E; IN4; IN5; IN6A; IN7; IN8; IN9B; IN11; IN12A; IN12B; IN14; EX4A; F5)	T02 ISO 5658-2	*CFE* kWm^{-2}	Minimum	20 a	20 a	20 a
	T03.01 ISO 5660-1: 50 kWm^{-2}	*MARHE* kWm^{-2}	Maximum	-	90	60
	T10.01 EN ISO 5659-2: 50 kWm^{-2}	$D_s(4)$ dimensionless	Maximum	600	300	150
	T10.02 EN ISO 5659-2: 50 kWm^{-2}	*VOF4* min	Maximum	1 200	600	300
	T11.01 EN 17084 Method 1 50 kWm^{-2}	CIT_G dimensionless	Maximum	1,2	0,9	0,75

R7 (IN6B; IN12C; EX1A; EX1C; EX3; EX4B; EX5; EX6A; EX7; EX8; EL3C)	T02 ISO 5658-2	*CFE* kWm^{-2}	Minimum	20 a	20 a	20 a
	T03.01 ISO 5660-1: 50 kWm^{-2}	*MARHE* kWm^{-2}	Maximum	–	90	60
	T10.04 EN ISO 5659-2: 50 kWm^{-2}	D_s max. dimensionless	Maximum	–	600	300
	T11.01 EN 17084 Method 1 50 kWm^{-2}	CIT_G dimensionless	Maximum	–	1,8	1,5

Mechanical Properties

- PN-EN ISO 2808:2019 – Paints and varnishes – Documentation of film thickness
- PN-EN ISO 4624:2016 – Paints and varnishes – Pull-off test for adhesion
- PN-EN ISO 6272:2011 – Paints and varnishes – Rapid deformation (impact resistance) test
- PN-EN 13261:2009+A1:2010 – Railway applications – Wheelsets and bogies – Axles – Product requirements

Hydroxide Additives

$$2Al(OH)_3 \xrightarrow{\Delta T} Al_2O_3 + 3H_2O$$

$$Mg(OH)_2 \xrightarrow{\Delta T} MgO + H_2O$$

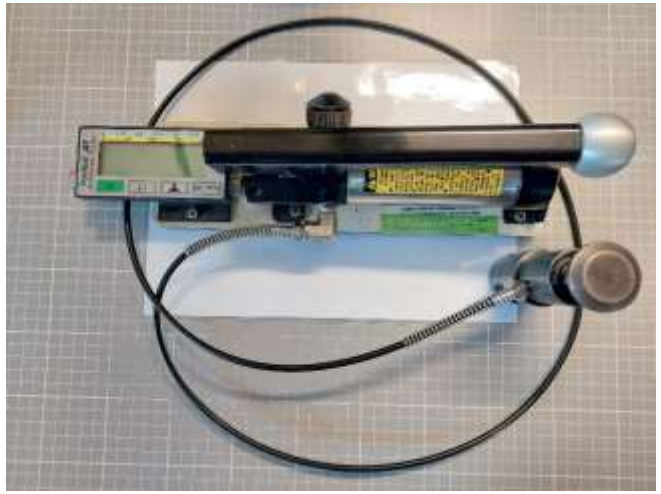
Experimental Design Methods (DOE)

F.H. BARWA

2k factorial design for two independent variables

System	Aluminium Hydroxide	Magnesium Hydroxide
0	0	0
1	1	0
2	0	1
3	1	1

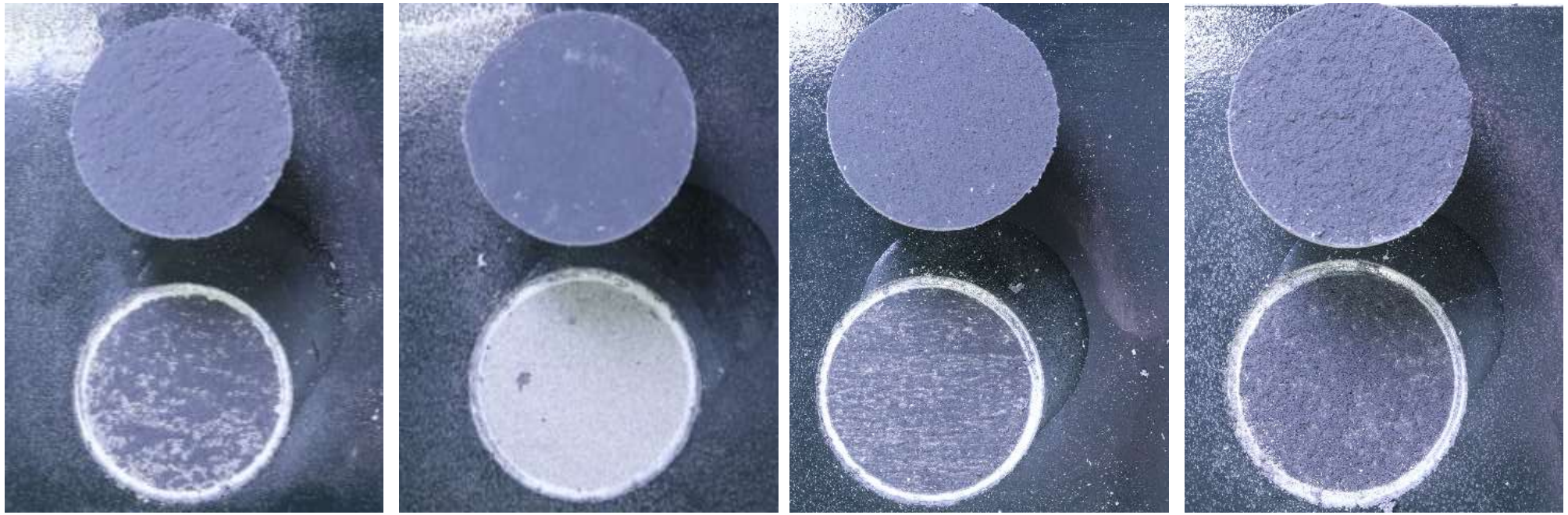
Measuring instruments



Film thickness

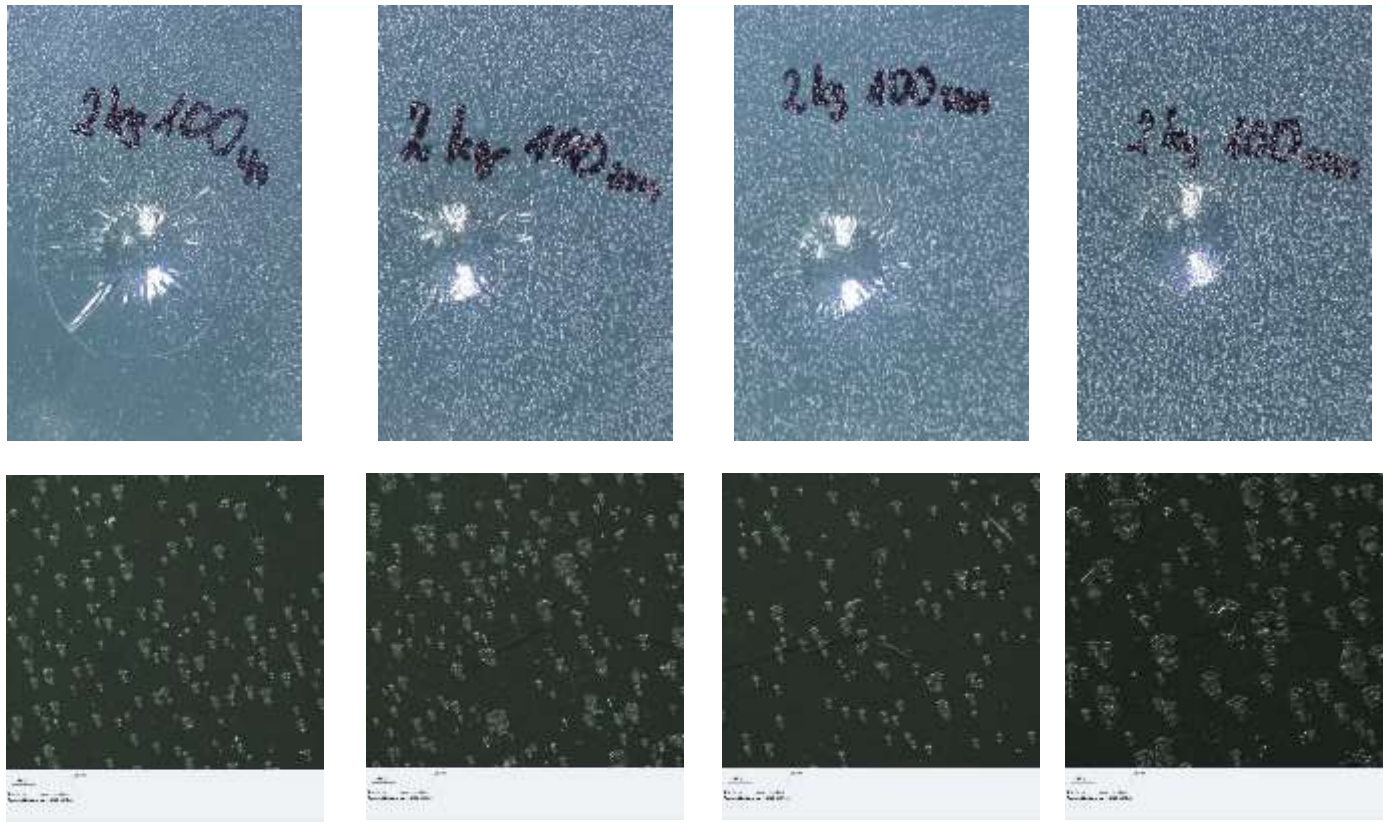
System	Average thickness [µm]		
	Anticorrosive Primer	Deafening Mass	Topcoat
0	42,8	1429,1	48,4
1	47,3	1396,8	46,1
2	45,3	1389,7	45,5
3	45,5	1365,8	44,3
Average:	45,2	1395,3	46,1

Pull-off test



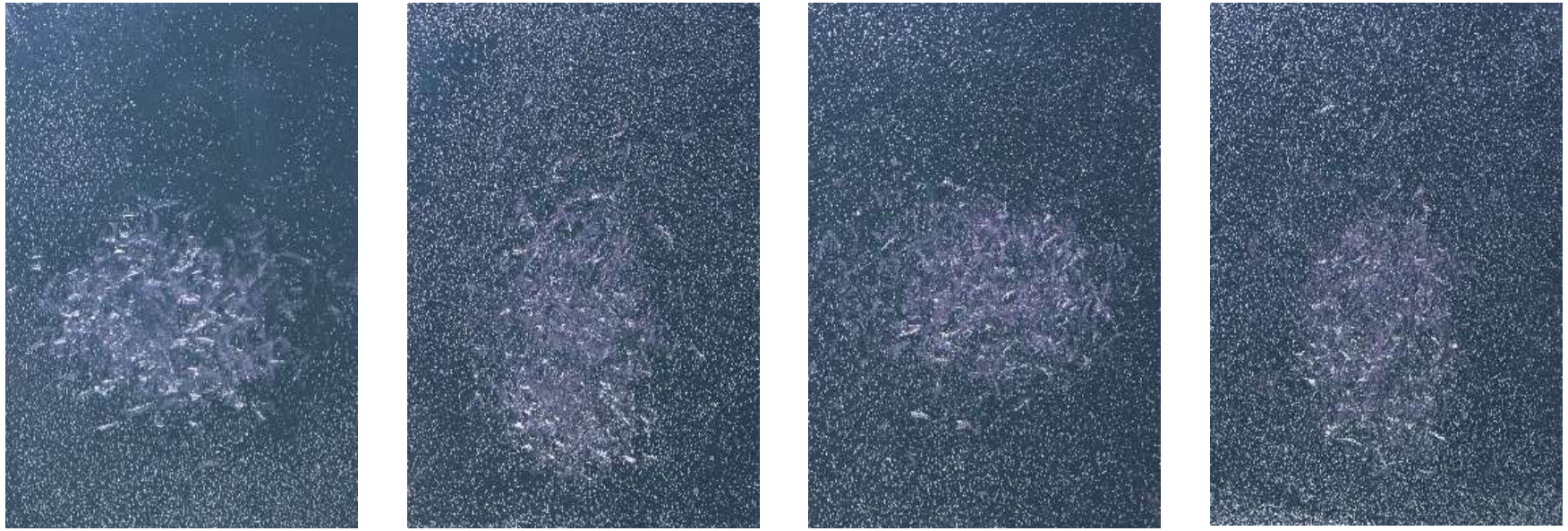
From the left: System 0 average value 0.82 MPa; System 1 average value 1.01 MPa; System 2 average value 0.61 MPa; System 3 average value 0.80 MPa.

Rapid deformation test



The top row shows the front shots 2 kg 100 cm and the bottom row the rear shots 1 kg 10 cm.
From the left: System 0; System 1; System 2; System 3.

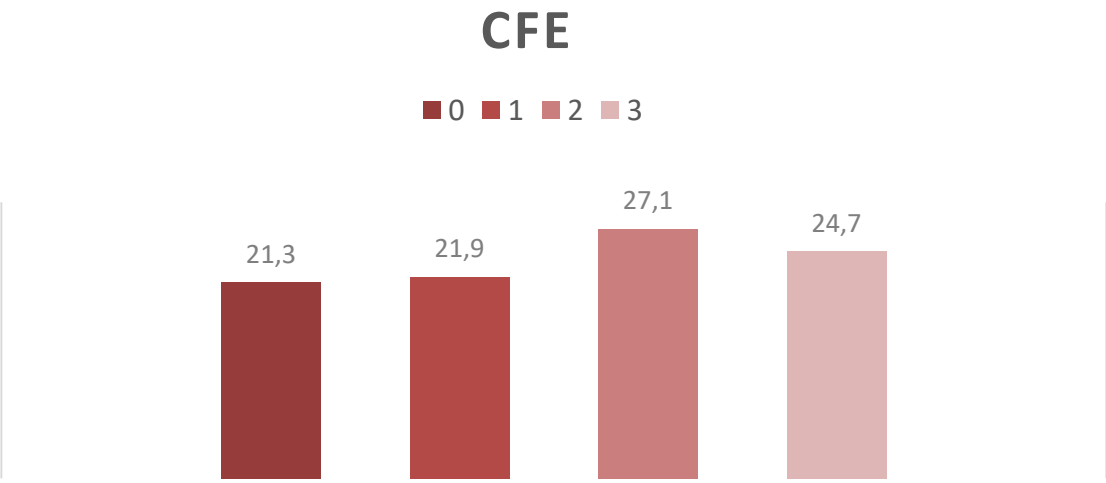
Resistance to gritting



From the left: System 0; System 1; System 2; System 3

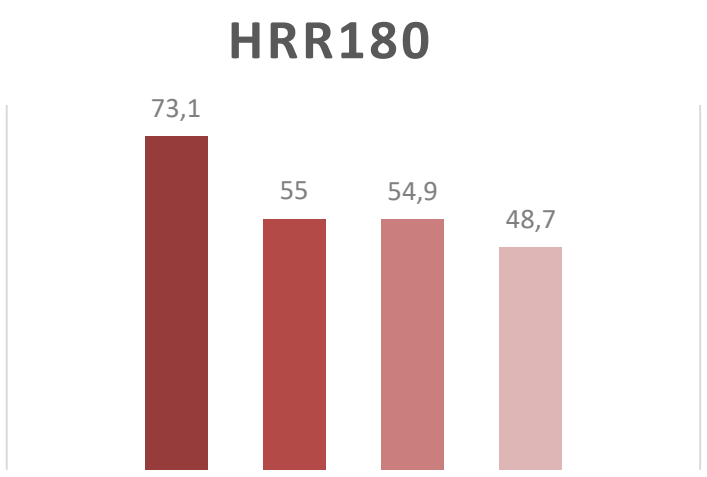
Lateral Propagation Of Flame

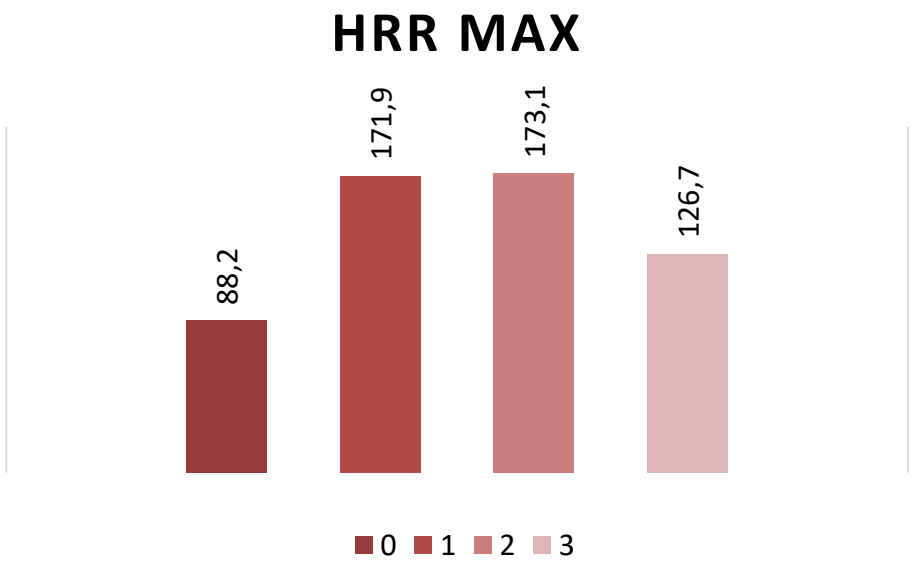
System	Average thickness, mm	Ignition time t_o, s	Time of flame extinction t_k, s	Burning time t, s	CFE, kW/m^2
0	2,99	47	666	619	21,3
1	2,70	56	639	583	21,9
2	2,71	60	602	542	27,1
3	2,89	71	530	459	24,7

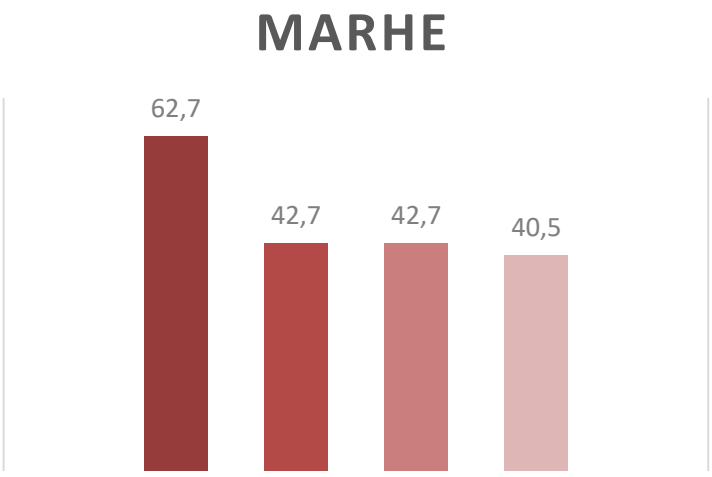


Intensity Of Heat Release

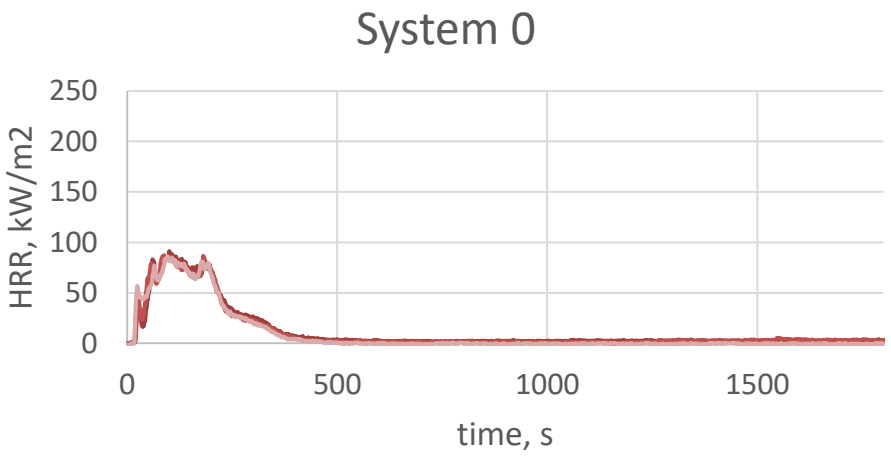
System	Average thickness, mm	HRR_{180}, kW/m²	HRR_{max}, kW/m²	MARHE kW/m²
0	3,00	73,10	88,24	62,7
1	2,91	55,04	171,91	42,7
2	2,98	54,89	173,10	42,7
3	2,87	48,65	126,69	40,5

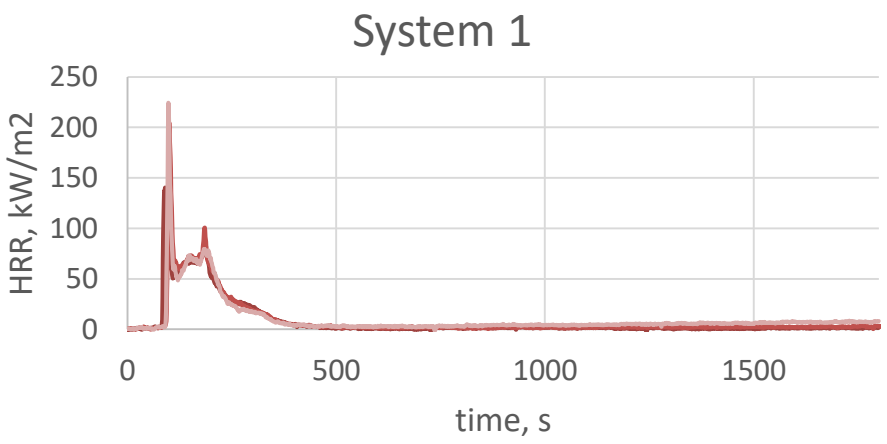


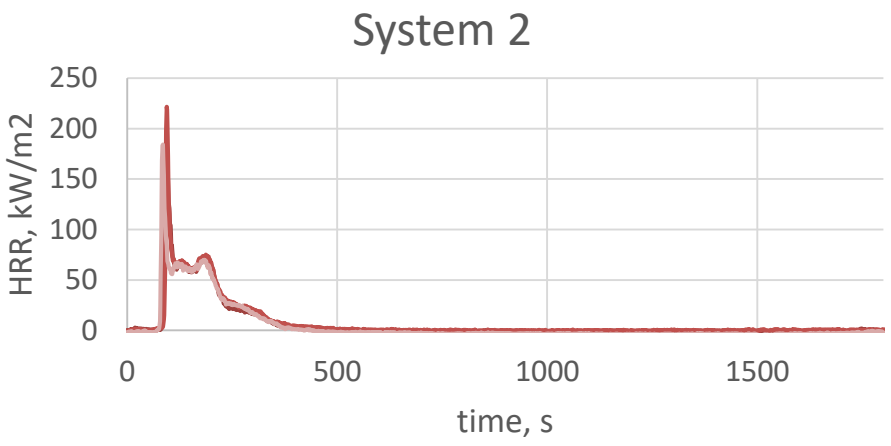


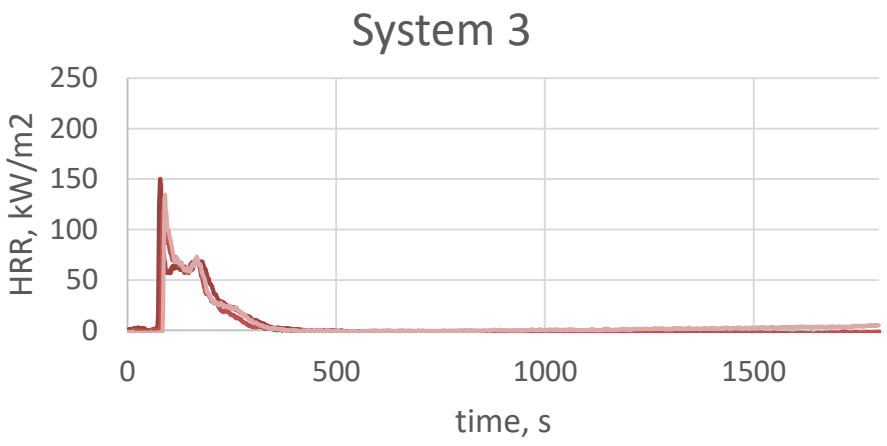


Intensity Of Heat Release



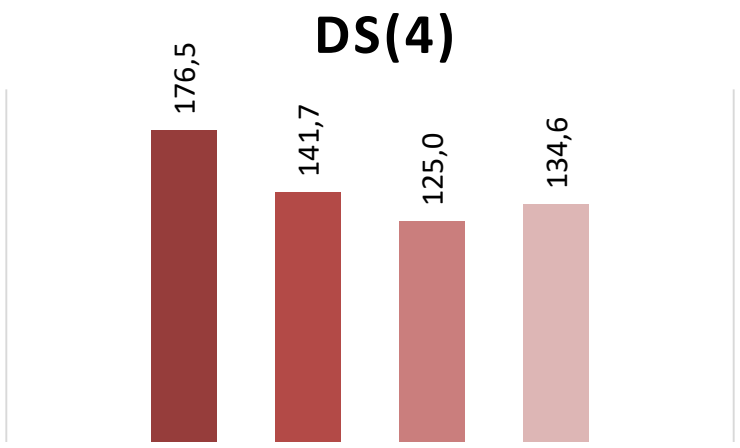


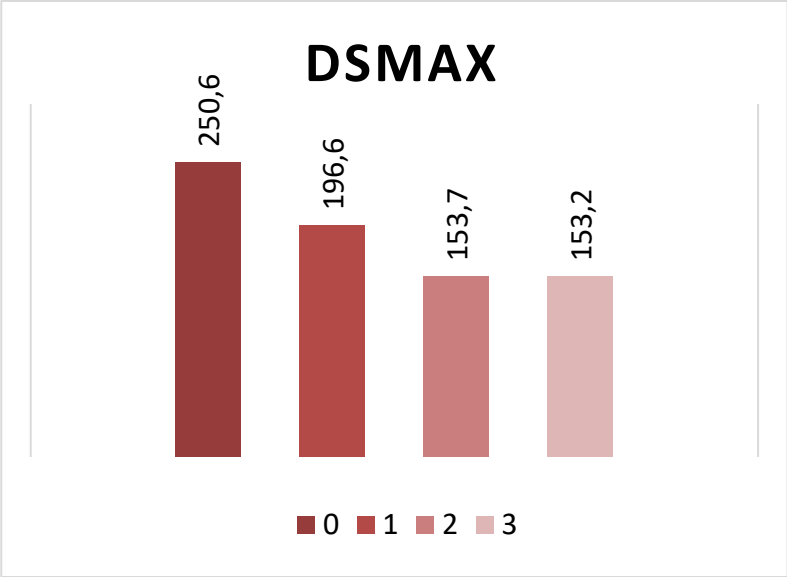


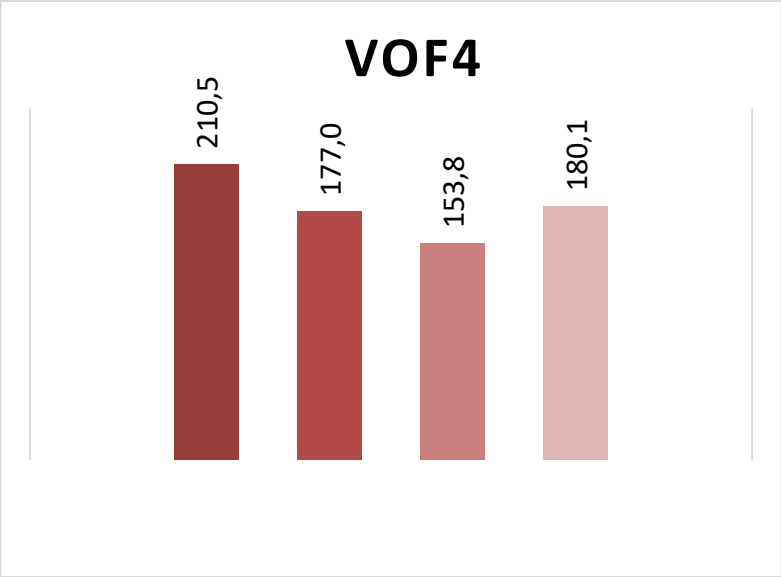


Generated Fumes And Gases

System	Average thickness, mm	$D_S(4)$	D_S max	VOF(4)
0	2,96	176,53	250,62	210,45
1	3,01	141,69	196,61	176,98
2	3,04	125,01	153,65	153,78
3	2,86	134,55	153,22	180,07







Conclusions

- Positive influence of additives on fire properties
- Negative or neutral influence of additives on mechanical properties
- Need for further research

Bibliography

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Thank you for your attention!