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INSTYTUT KOLEJNICTWA

Materials and Structure Laboratory
LK
Section of Non-metal Materials

AB 369

Laboratory approved by CERTIFER Railway Certification

Replaces IK.LKA68.A93/23

TEST REPORT No IK.LKA68.A93/23-1
Fire properties

Customer:	WIKO Klebetechnik Sp. z o.o., 42-271 Częstochowa, Ekonomiczna 8, Poland
Order:	signed on 28.09.2023 contract No. IK.OFR.22.0310.00.2023 from 19.07.2023
Tested material:	the samples of sandwich (steel + glue + steel), thickness about 6 mm
Description of tested material:	according sampling protocol of tests dated 21.09.2023: •Steel, thickness 2 mm, •Weldyx Master glue, thickness 2 mm •Steel, thickness 2 mm
Manufacturer:	WIKO Klebetechnik Sp. z o.o., 42-271 Częstochowa, Ekonomiczna 8, Poland
Application:	R1, R7 according to the requirements of PN-EN 45545-2:2021-01
The test methods:	ISO 5658-2:2006 Reaction to fire tests – Spread of flame – Part 2: Lateral spread on building and transport products in vertical configuration, ISO 5660-1:2015+Amd1:2019-08 Plastics – Reaction-to-fire tests-Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement); PN-EN 45545-2:2021-01 p. 5.1, p. 5.2.1.1 Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behaviour of materials and components, PN-EN ISO 5659-2:2017-08 Plastics - Smoke generation – Part 2: Determination of optical density by a single-chamber test; PN-EN 17084:2019-02 Railway applications – Fire protection on railway vehicles – Toxicity test of materials and components Method 1
Range of tests:	maximum average rate of heat emission MARHE $^{(A)}$, critical flux at extinguishment CFE$^{(A)}$, optical density after the first 4 min. $D_s(4)$ $^{(A)}$, specific optical densities at the first 4 min. $(VOF_4)^{(A)}$, maximum optical density $D_smax^{(A)}$, conventional index of toxicity $CIT_G^{(A)}$
Date and way of samples delivery for testing:	the samples delivered on 22.09.2023 by the Customer with sampling protocol for tests from 21.09.2023
Dates of tests realization:	05.10.2023, 09.10.2023, 11.10.2023

$^{(A)}$ - test accredited

The change was made at the request of the Customer of 14.05.2024, the report was extended to include R7 requirement.

Report includes 11 pages numbered.

Warsaw, 19th of October 2023, issue 2 of 20th of May 2024

LATERAL SPREAD ON PRODUCTS IN VERTICAL CONFIGURATION

The test method: ISO 5658-2:2006
Test samples preparing conditions: conditioning - temperature (23,0±1,0)^{0}C and humidity (50±2,2)% during 167 h
Conditions during the test: temperature (22,4±0,2)^{0}C, humidity (36,5±1,0)%, heat flux: 50,9 kW/m^2
Apparatus: stand for testing lateral flame spread in vertical orientation, pilot burner powered by propane gas, termohygrometer, meter stick, anemometer

TEST RESULTS

Tab.1 Time to reach peculiar flame range

Range of flame, mm	Time to reach flame range, s					
	Sample					
	A93.3/23	A93.4/23	A93.5/23	A93.1/23	A93.2/23	A93.6/23
50	470	558	501	600	623	526
100	501	560	503	601	625	627
150	503	563	532	602	626	628
200	663	606	536	603	631	628
250	899	654	594	657	646	629
300	-	656	595	-	670	642
350	-	656	597	-	693	642
400	-	-	611	-	698	643
450	-	-	622	-	715	
500	-	-	-	-	-	
550	-	-	-	-	-	
600	-	-	-	-	-	
650	-	-	-	-	-	
700	-	-	-	-	-	
750	-	-	-	-	-	

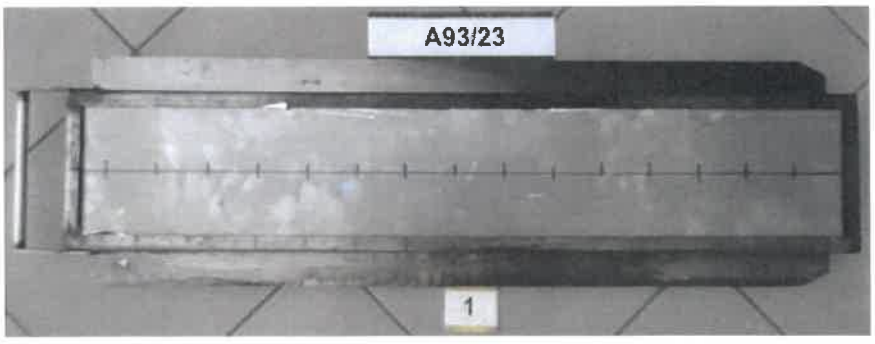

Fig. 1. Sample before the test.

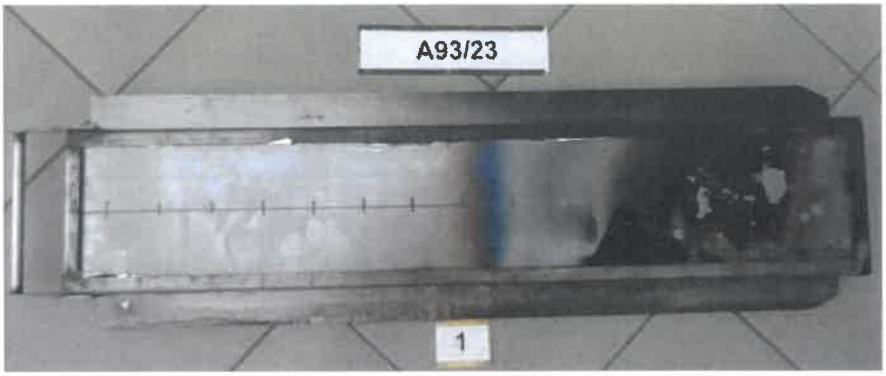

Fig. 2. Sample after the test.

Tab.2 Final test results

Symbol	Parameters	Sample						Uncertainty of measurement of the probability 95% and k=2	Test result
		A93.3/23	A93.4/23	A93.5/23	A93.1/23	A93.2/23	A93.6/23		
		1	2	3	4	5	6		
CFE	Critical heat flux at extinguishment, kW/m^2	37,6	21,0	11,1	37,1	11,5	10,9	± 7,4%	**21,5 ± 1,6**
Q_{sp}	Heat for sustained burning, MJ/m^2	26,3	22,7	19,1	27,4	21,9	21,3		**23,1 ± 1,7**
t_0	Ignition time, s	430	509	457	501	562	467	± 1s	**488 ± 1**
t_k	Flameout time, s	1800	1800	1670	1800	1800	1800	± 1s	**1778 ± 1**
t	Test time, s	1800	1800	1800	1800	1800	1800	± 1s	**1800 ± 1**
L	Range of flame, mm	253	376	476	256	471	480	± 10 mm	**385 ± 10**

Observations: no atypical behavior occurred during the test

Test carried out by:

D. Zagdański Techn.

A. Świetlik M. Sc Eng.....

11.10.2023

INTENSITY OF HEAT RELEASE

The test method: ISO 5660-1:2015+Amd:2019-08, PN-EN 45545-2:2021-01 p. 5.1, p. 5.2.1.1
Test samples preparing conditions: conditioning - temperature (23,0±1,0)^{0}C and humidity (50±2,2)% during 23 h
Conditions during the test: temperature (22,5±0,2)^{0}C, humidity (42,3±1,3)%
nominal duct flow rate: 0,024 m^3/s
orientation: horizontal
surface area: 0,0088 m^2,
heat flux: 50 kW/m^2,

Apparatus: cone calorimeter iCONE MINI, FTT (Great Britain), termohygrometer, weight, caliper

Calibration data:

C-factor: 0,04138

Conversion coefficient: 13,1 MJ/kg

	A93.7/23	A93.9/23	A93.11/23
	1	2	3
Baseline oxygen O_2, %:	20,955	20,949	20,949
Mass (with aluminium foil)	335,1	333,3	330,4
Thickness	6,25	6,17	5,79
Density	-		-

The following print data are attached to the test report:

App. 1 Heat release rate graph (HRR)

App. 2 Smoke production rate (SPR)

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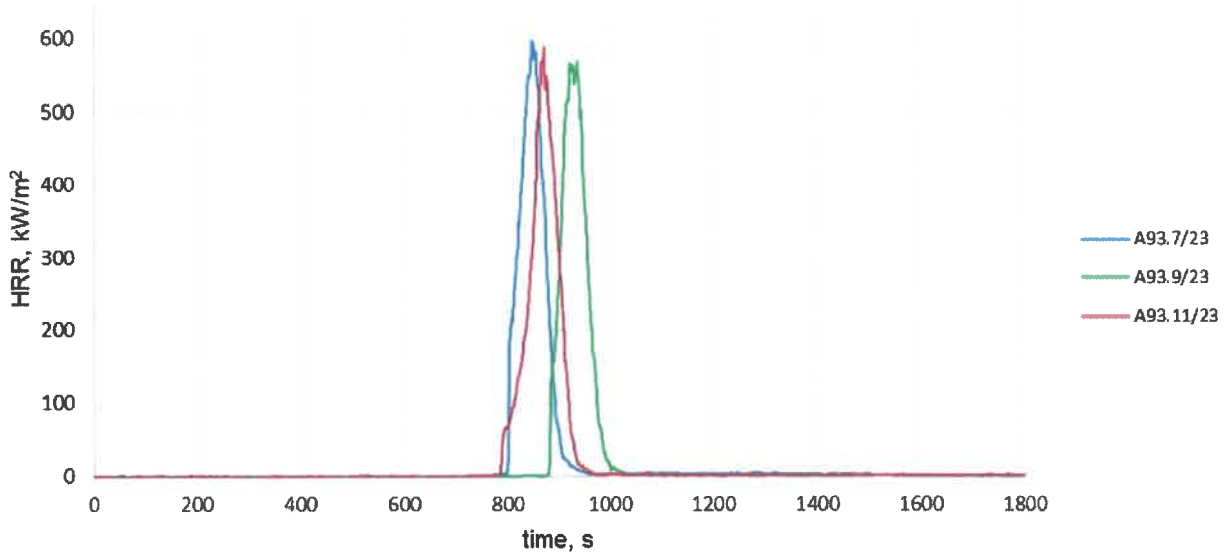
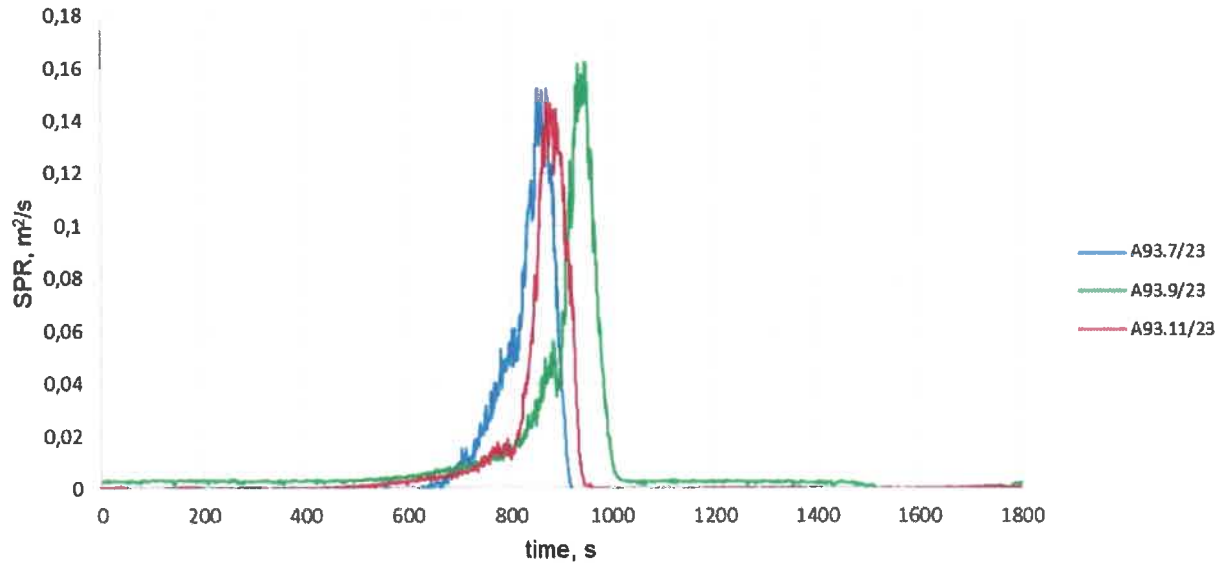
A93/23 HRR for heat flux 50 kW/m²



A93/23 SPR for heat flux 50 kW/m²



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TEST RESULTS

Symbol	Parameters	Sample			Average values	Uncertainty of measurement of the probability 95% and k=2 for parameters according to ISO 5660-1:2015
		A93.7/23	A93.9/23	A93.11/23		
		1	2	3		
HRR_{max}	Maximum heat release rate, kW/m²	595,9	568,6	587,0	583,8	± 48,5
$HRR_{śr}$	Average heat release rate, kW/m²	36,2	36,5	37,8	36,8	± 3,1
HRR_{180}	Average heat release rate at 180 s, kW/m²	189,2	183,3	204,5	192,3	± 16,0
HRR_{300}	Average heat release rate at 300 s, kW/m²	114,8	110,3	123,5	116,2	± 9,6
THR	Total heat release, MJ/m²	35,8	33,3	37,9	35,7	–
ML	Mass loss, g/m²	1640,6	1636,3	1692,9	1656,6	± 130,9
MLR	Mass loss rate, g/s m²	1,66	1,80	1,68	1,71	± 0,1
MLR ($m_{A,10\text{-}90}$)	Average specific mass loss rate, g/s m²	19,9	20,8	16,9	19,2	± 1,5
$S_{A,1}$	Total smoke release in non-flaming phase, m²/ m²	398,4	674,2	176,1	416,2	± 7,9
$S_{A,2}$	Total smoke release in flaming phase, m²/ m²	1071,9	1241,5	1230,1	1181,2	± 22,4
S_a	Total smoke release, m²/ m²	1470,3	1915,7	1406,2	1597,4	± 30,4
m_s	Mass at susitained flaming, g	327,2	327,1	327,0	327,1	–
m_f	End mass, g	313,5	312,2	310,7	312,1	–
t_{ig}	Ignition time, s	811	891	797	833	–
$t_{f.\,out}$	Time to flameout	972	1060	980	1004	-
t	End of test time, s	2772	2691	2597	2687	–
MARHE	**Maximum average rate of heat emission, kW/m²**	**38,8**	**34,2**	**39,7**	**37,6**	**± 3,1**

Observations: very high flame at the beginning of burning (above cone height)

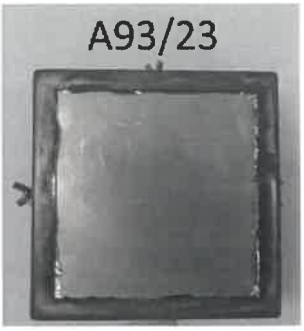

Fig. 1. Sample before the test.

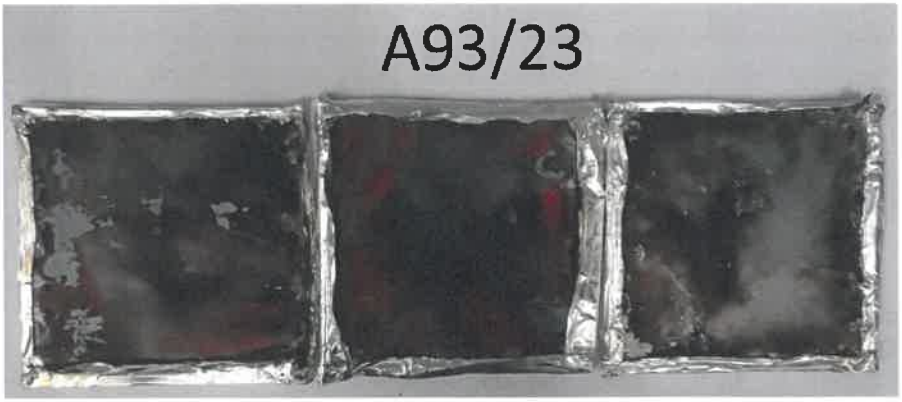

Fig. 2. Samples after the test.

Test carried out by:

M. Łyszcz M. Sc Eng. Marta Łyszcz

05.10.2023

OPTICAL DENSITY OF SMOKE

The test method: PN-EN ISO 5659-2:2017-08
Test samples preparing conditions: conditioning - temperature (23,0±1,0)^{0}C and humidity (50±2,2)% during 119 h
Conditions during the test: temperature (18,2±0,2)^{0}C, humidity (37,7±1,0)%, C_f: 3,04; heat flux: 50 kW/m^2 without pilot flame, method of fixing the specimen: without wire mesh, substrate used: insulating board and refractory-fibre blanket, non-intumescent material, the tested surface of the sample: exposed
Apparatus: smoke chamber, thermohygrometer, caliper, weight

TEST RESULT

Symbol	Parameters	Sample			Average value	Np.*
		A93.13/23	A93.14/23	A93.15/23		
		1	2	3		
m_p	Mass of sample, g	184,4	181,2	185,3	183,6	-
m_k	End mass, g	184,3	181,1	185,2	183,5	-
σ m	Mass loss, g	0,1	0,1	0,1	0,1	-
g	Thickness of sample, mm	5,8	5,9	5,8	5,8	-
t_0	Ignition time, s	-	-	-	-	-
t_k	Flameout time, s	-	-	-	-	-
t	Duration of the test, s	600	600	600	600	-
D_c	Clear beam specific optical density	1,3	2,7	1,0	1,7	-
$D_s$max	Maximum specific optical density	52,9	25,5	47,4	41,9	**± 2,0**
D_s (4)	Specific optical density after 4 min.	0,4	0,6	0,5	0,5	**± 0,02**
VOF_4	Total value of specific optical density in the first 4 min., min.	1,2	1,8	1,6	1,5	**± 0,07**

Np.*- Uncertainty of measurement of the probability 95% and k=2

Observations: very high flame at the beginning of burning (above cone height)

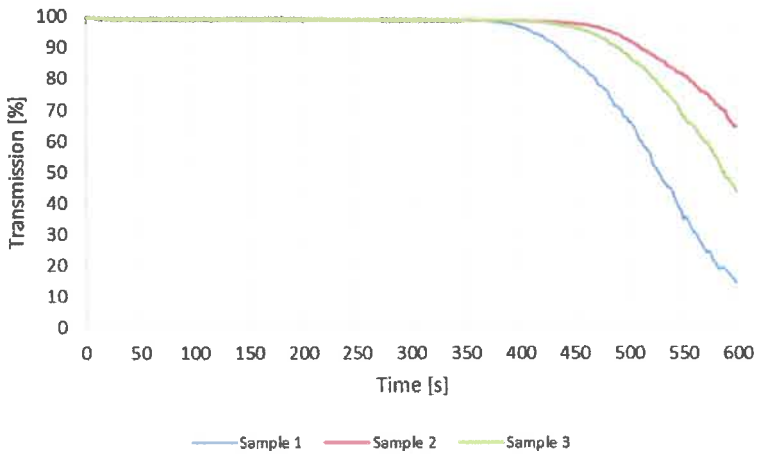

Fig. 1. Graph of light transmission during the test.

Fig. 2. Sample before the test.

Fig. 3. Samples after the test.

Test carried out by:

M. Łyszcz M. Sc Eng .....

09.10.2023

GAS ANALYSIS IN THE SMOKE CHAMBER USING FTIR TECHNIQUE

The test method: PN-EN 17084:2019-02 Method 1
Test samples preparing conditions: conditioning - temperature (23,0±1,0)^{0}C and humidity (50±2,2)% during 119 h
Conditions during the test: temperature (18,2±0,2)^{0}C, humidity (37,7±1,0)%,
Irradiance level: heat flux: 50 without pilot flame; distance to source of specimen: 25 mm, method of fixing the specimen: without wire mesh, substrate used: insulating board and refractory-fibre blanket, non-intumescent material, the tested surface of the sample: exposed
Apparatus: smoke chamber, termohygrometer, caliper, weight, FTIR chamber

TEST RESULTS

Tab 1. Volumetric fraction (φ) of each gas according p. 4.2 PN-EN 17084:2019-02, ppm v/v at 4, 8 min

Gas/sample	Detection limit	Gas limits of detection by FTIR					
		4 min			8 min		
		A93.13/23	**A93.14/23**	**A93.15/23**	**A93.13/23**	**A93.14/23**	**A93.15/23**
CO	5 ppm	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
CO_2	10 ppm	18,2	n.w.	7,0	54,5	22,8	33,8
HCN	5 ppm	n.w	n.w	n.w	n.w.	n.w.	n.w.
SO_2	5 ppm	5,1	6,1	n.w	n.w.	5,4	n.w
HCl	5 ppm	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
HF	5 ppm	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
HBr	5 ppm	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
NO_x	18 ppm	n.w.	n.w	n.w	n.w	n.w	n.w.

Tab 2. Mass concentration (C_m) of each gas according 4.2 PN-EN 17084:2019-02, mg/m^3 at 4, 8 min

Gas/sample	4 min			8 min		
	A93.13/23	**A93.14/23**	**A93.15/23**	**A93.13/23**	**A93.14/23**	**A93.15/23**
CO	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
CO_2	28,7	n.w.	10,8	84,9	35,0	51,4
HCN	n.w	n.w	n.w	n.w.	n.w.	n.w.
SO_2	11,6	13,7	n.w	n.w.	n.w	n.w
HCl	n.w.	n.w.	n.w.	n.w.	12,1	n.w.
HF	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
HBr	n.w.	n.w.	n.w.	n.w.	n.w.	n.w.
NO_x	n.w.	n.w	n.w	n.w	n.w	n.w.

Description:
n.w. – under detection limit

Tab 3. Conventional Toxicity Index CIT_G at 4 and 8 min.

Parameter	**Sample**			**Uncertainty of measurement of the probability 95% and k=2**	**Test result**
	A93.13/23	**A93.14/23**	**A93.15/23**		
CIT $_{G(4)}$	0,005	0,006	0,002	**± 8,7%**	0,004±0,0004
CIT $_{G(8)}$	0,006	0,006	0,008		0,007±0,0006

Observations: no atypical behavior occurred during the test

Test carried out by:
M. Łyszcz M. Sc Eng ..... Marek Łyszcz .....
09.10.2023

FINAL RESULTS

Requirement	Standard	Parameter	Test result	HL Classification according to PN-EN 45545-2:2021-01		
				HL1	HL2	HL3
R1	T02 ISO 5658-2	CFE, kWm^{-2}	**21,5 ± 1,6**	≥20	≥20	≥20
	T03.01 ISO 5660-1	MARHE, kWm^{-2}	**37,6 ± 3,1**	-	≤90	≤60
	T10.01 PN-EN ISO 5659-2	Ds.(4) (-)	**0,5 ± 0,02**	≤600	≤300	≤150
		VOF4 (min.)	**1,5 ± 0,07**	≤1200	≤600	≤300
	T11.01 PN-EN 17084 Method 1	CIT_G (-)	**0,007±0,0006**	≤1,2	≤0,9	≤0,75
R7	T02 ISO 5658-2	CFE, kWm^{-2}	**21,5 ± 1,6**	≥20	≥20	≥20
	T03.01 ISO 5660-1	MARHE, kWm^{-2}	**37,6 ± 3,1**	-	≤90	≤60
	T10.04 PN-EN ISO 5659-2	Ds.max. (-)	**41,9± 2,0**	-	≤600	≤300
	T11.01 PN-EN 17084 Method 1	CIT_G (-)	**0,007±0,0006**	-	≤1,8	≤1,5
The obtained results meet the requirements R1 and R7 according to PN-EN 45545-2:2021-01 for the Hazard Level HL1, HL2 and HL3.						

Compliance with the standard PN-EN 45545-2:2021-01 with simple acceptance method according to ILAC G8:09/2019 stated by:

M. Łyszcz M. Sc Eng. .....

19.10.2023

The test results refer to the behavior of the product test specimens under specific test conditions; cannot be the only criterion for assessing the potential fire hazard of the product used.

Report authorized by:

KIEROWNIK PRACOWNI
MATERIAŁÓW NIEMETALOWYCH
LABORATORIUM BADAŃ MATERIAŁÓW
I ELEMENTÓW KONSTRUKCJI

mgr Danuta Milczarek

.....

Danuta Milczarek M. Sc

Report approved by:
Head of Laboratory LK:

KIEROWNIK
LABORATORIUM BADAŃ MATERIAŁÓW
I ELEMENTÓW KONSTRUKCJI

dr inż. Jolanta Radziszewska-Wolińska
profesor Instytutu Kolejnictwa

.....

Professor of IK, Jolanta Radziszewska-Wolińska Ph. D. Eng.