Solkane® 365mfc based solutions as alternative to HCFC141b

economical, ecological and technical considerations

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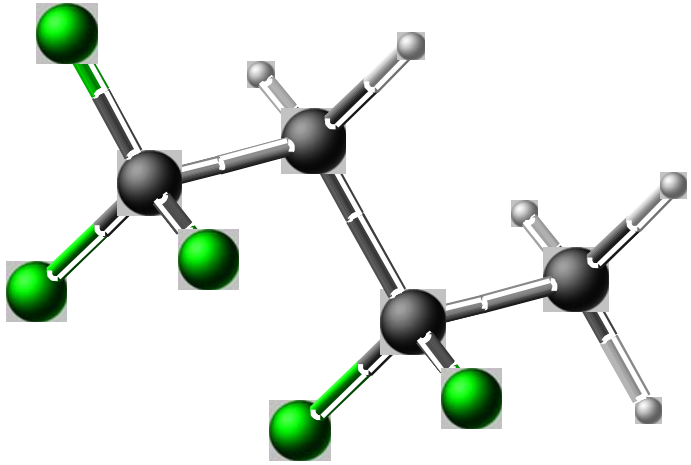


- Physical data - blowing agents in comparison
- Blowing agents in foams
- Co-Blowing
- Safety and handling
- Flammability in systems

Physical properties in comparison

	HCFC-141b	HFC-365mfc	HFC-245fa	HFC-134a	HFC-227ea
Structure	CCl_2F-CH_3	CF_3-CH_2-CF_2-CH_3	CF_3-CH_2-CF_2H	CF_3-CFH_2	CF_3-CFH-CF_3
Mol.-Weight	116,9	148	134	102	170
Boiling Point [°C]	31,7	40,2	15,3	-26,1	-17,0
Vapour pressure at 20 °C [bar]	0,6	0,4	1,2	5,7	3,9
lambda [gas at 25 °C]	9,5	10,6	12,2	13,4	12,7
Flash point	none	-27	none	none	none
Flammability limits [% by volume]	7,4 - 17,7	3,6 - 13,3	none	none	none

Physical properties in comparison

	HCFC-141b	HFC-365mfc	n-pentane	i-pentane	c-pentane
Structure	$CCl_2F\text{-}CH_3$	$CF_3\text{-}CH_2\text{-}CF_2\text{-}CH_3$	$CH_3\text{-}(CH_2)_3\text{-}CH_3$	$CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_3$	
Mol.-Weight	116,9	148	72	72	70
Boiling Point [°C]	31,7	40,2	36,1	27,8	49,5
Vapour pressure at 20 °C [bar]	0,6	0,4	0,6	0,8	0,35
lambda at 25 °C [mW/m.K]	9,5	10,6	15,2	14,7	12,0
Flash point [°C]	none	-27	-49	-57	-37
Flammability limits [% by volume]	7,4 - 17,7	3,6 - 13,3	1,4 - 7,8	1,4 - 8,3	1,4 - 8,3

Physical properties in comparison

	HCFC-141b	HFC-365mfc	Dimethoxymethane (Methylal)	Methylmethanoate (Methylformiate)
Structure	CCl_2F-CH_3	CF_3-CH_2-CF_2-CH_3	CH_3–O–CH_2–O–CH_3	CH_3OOCH
Mol.-Weight	116,9	148	76	60
Boiling Point [°C]	31,7	40,2	41	32
Vapour pressure at 20 °C [bar]	0,65	0,43	0,44	0,58
lambda at 25 °C [mW/m.K]	9,5	10,6	13,1	10,7
Flash point [°C]	none	-27	-18	-32
Flammability limits [% by volume]	7,4 - 17,7	3,6 - 13,3	2,2 – 19,9	5 - 23

Physical properties in comparison

	HCFC-141b	HFC-365mfc	HFC-245fa	n-Pentane	c-Pentane	Methylal	Methylformiate	
MW	116.95	148.08	134.05	72	70.14	76	60	
Bp	31.7	40.2	15.3	36.1	49.5	41	32	[°C]
k-Factor	9.5	10.6	12.2	15.2	12	13.1	10.7	[mW/m.K]
GWP	725	890	950	3 - 7	11	negligible	~ 1	
ODP	0.11	0	0	0	0	0	0	
VOC	no	no	no	yes	yes	yes	yes	
Flammability	none	yes	none	yes	yes	yes	yes	
LEL	5.6	3.6	-	1.4	1.4	2.2	5	[% by volume]
UEL	17.7	13.3	-	7.8	8.3	19.9	23	[% by volume]

Toxicology / Notification

	HCFC-141b	HFC-365mfc
Acute Toxicity, LC 50 (rats)	62 000 ppm	> 100 000 ppm
NOAEC chronic	7,3 g/m^3 (2 y)	90 g/m^3 (90 d)
Mutagenicity	negative	negative
Card.sens. (Threshold)	0,5 %	7,5 %
ELINCS – No.:	404-080-1	430-250-1

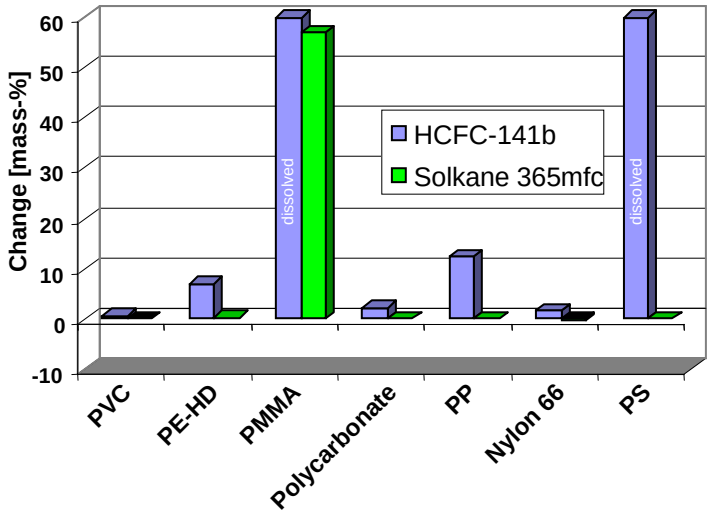
Commercial available Blends

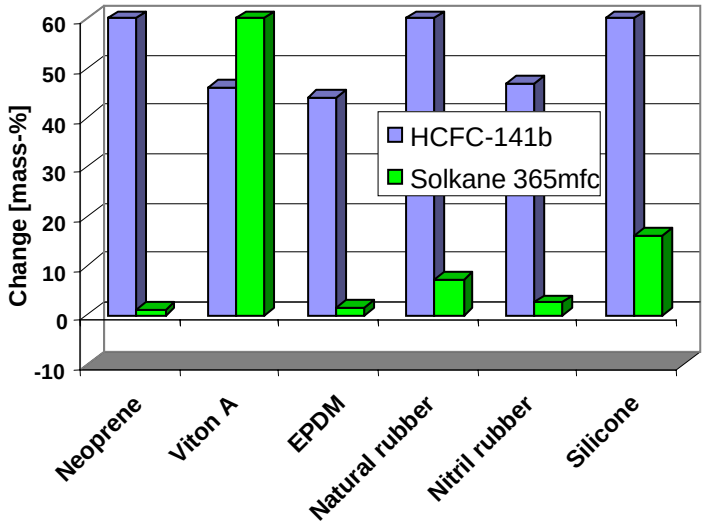
Product	Flammability	Recommendation
Solkane 365mfc	flammable	Additive for pentane boards
Solkane 365/227 93:7	non flammable	Foaming agent for direct production
Solkane 365/227 87:13	non flammable	Foaming agent for systems

Compatibility with materials

Materials	HCFC-141b	Solkane 365mfc
Thermoplastics		
PVC	0,77	-0,02
PE-HD	7,1	0,37
PMMA	dissolved	57
Polycarbonate	2,3	0,27
PP	12,5	0,16
Nylon 66	1,87	-0,33
PS	dissolved	0,19
Elastomers		
Neoprene	87	1,02
Viton A	46	90,5
EPDM	44	1,6
Natural rubber	185	7,2
Nitril rubber	47	2,5
Silicone	110	16,1

After 7 days immersion : (% by weight)





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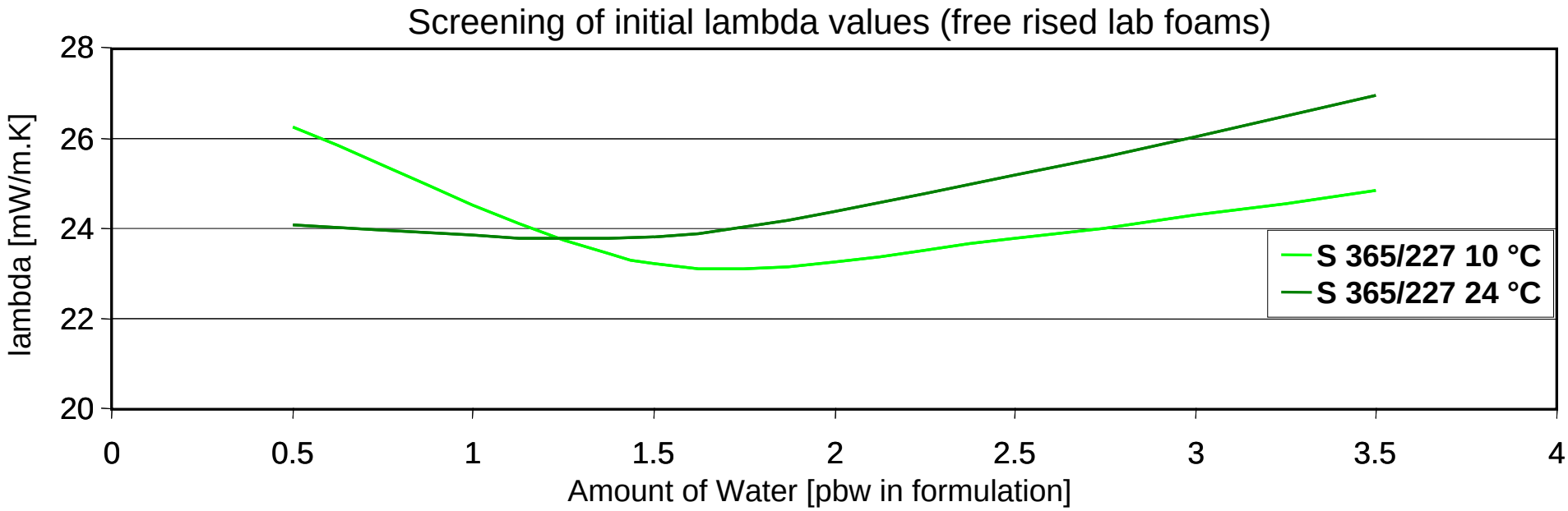
Solubility of Solkane 365mfc in comparison

	HCFC-141b	Solkane 365mfc	n-pentane	c-pentane
Polyether				
Daltolac 585-8	complete soluble	32	4,5	11
IXOL B251	3	0,3	1,4	2,2
IXOL M125	37	5,3	2,1	5,6
Tercarol A 350	complete soluble	complete soluble	36	complete soluble
Tercarol RF 55	complete soluble	complete soluble	4,5	18
Voranol RA 640	complete soluble	complete soluble	20	complete soluble
Polyester				
Repol 201-28	57	21	2,7	5,4
Stepanpol PS 3152	34	31	6,5	6,6
Terate 203	32	18	1,3	no data
Terate 2541	42	11	0,1	no data
Miscellaneous				
TCPP	complete soluble	complete soluble	10	complete soluble
MDI 44 V20	complete soluble	12	4,1	6,6
Dipropylene glycole	complete soluble	complete soluble	13	36

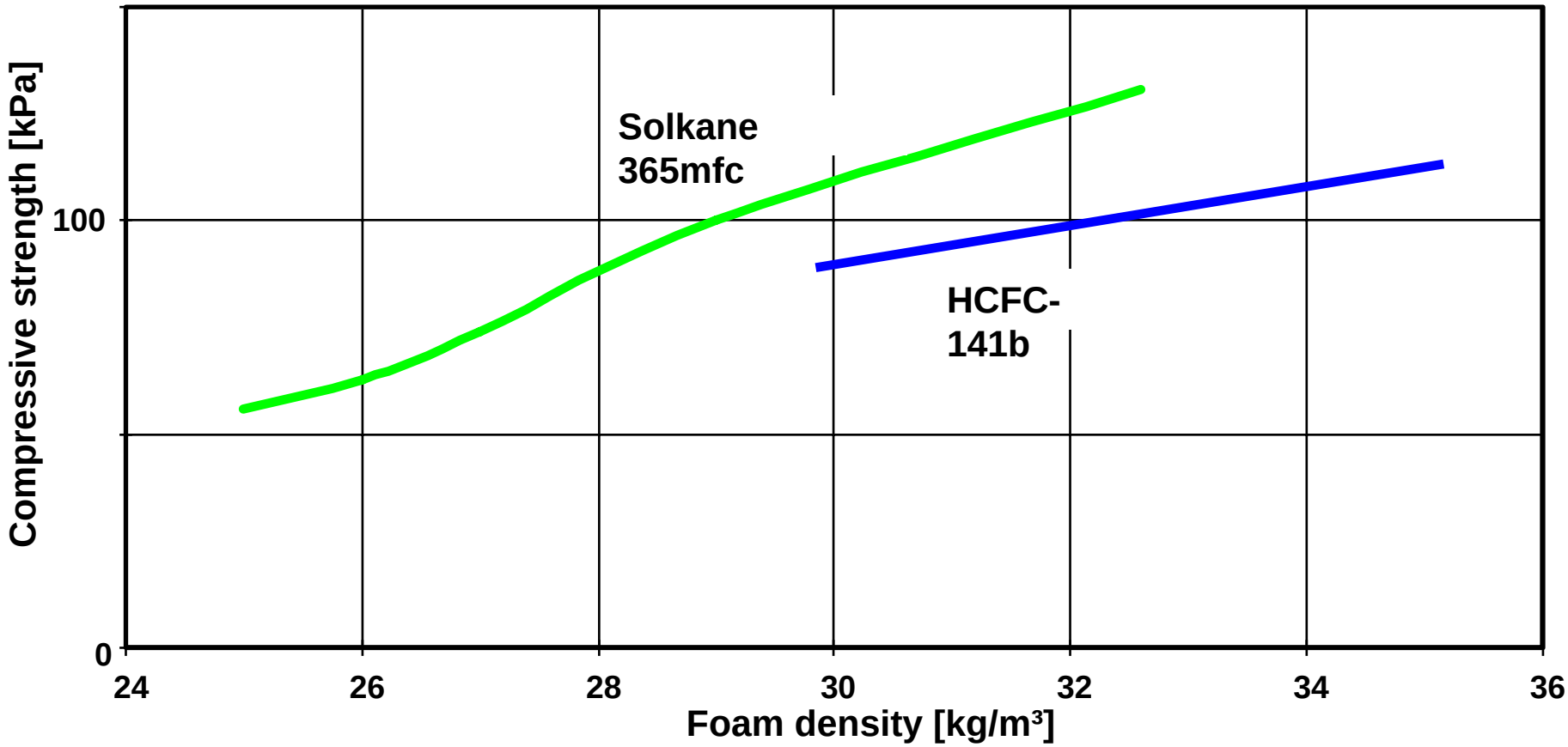
Strategies to phase out HCFC-141b

Step 1: exchange HCFC-141b with Solkane 365/227 in molar ratio 117 : 148

Step 2: exchange Solkane 365/227 stepwise with water to reduce density and adjust Comp. Strength in parallel

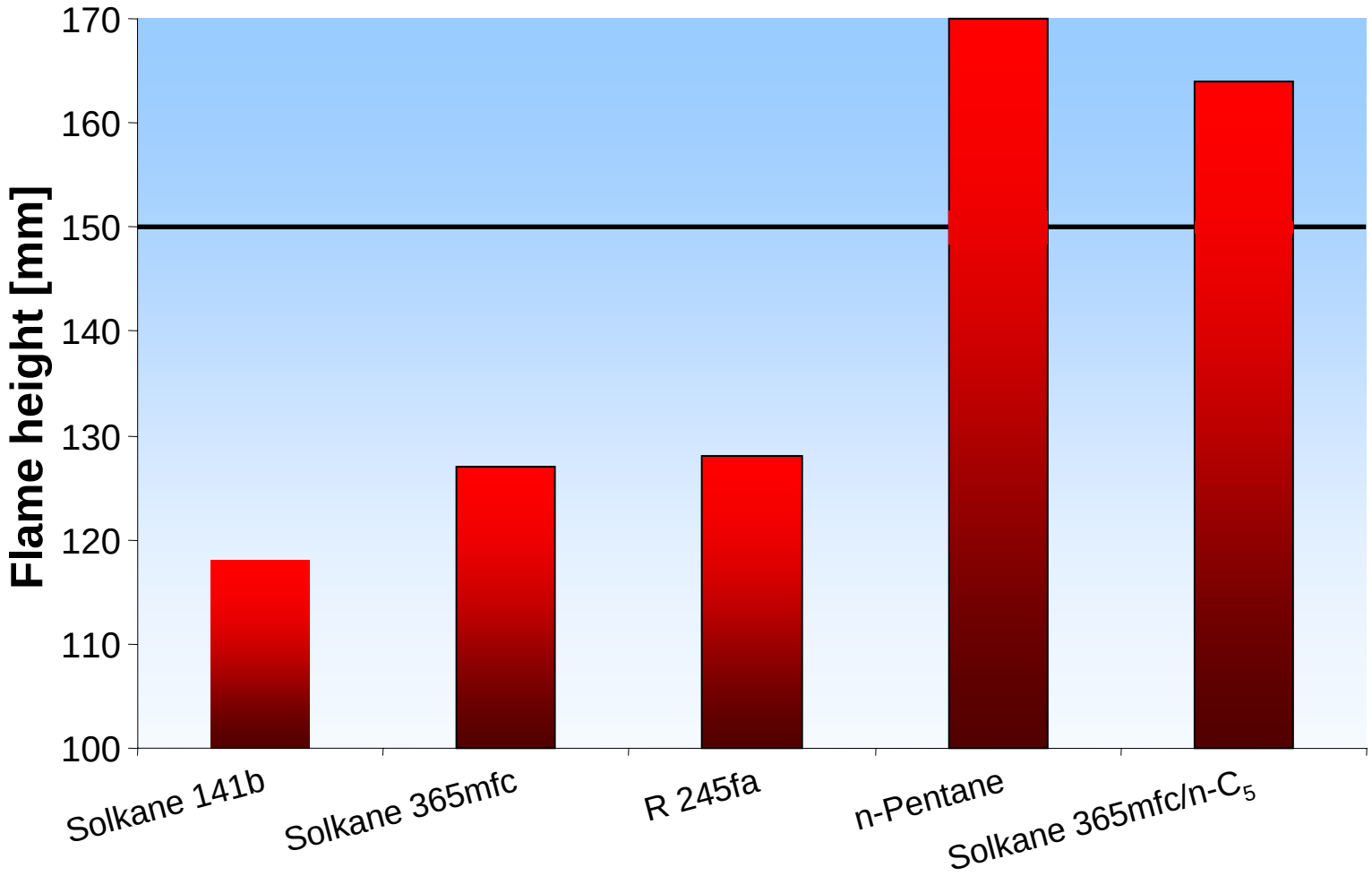


Influence of blowing agent to comp. strength



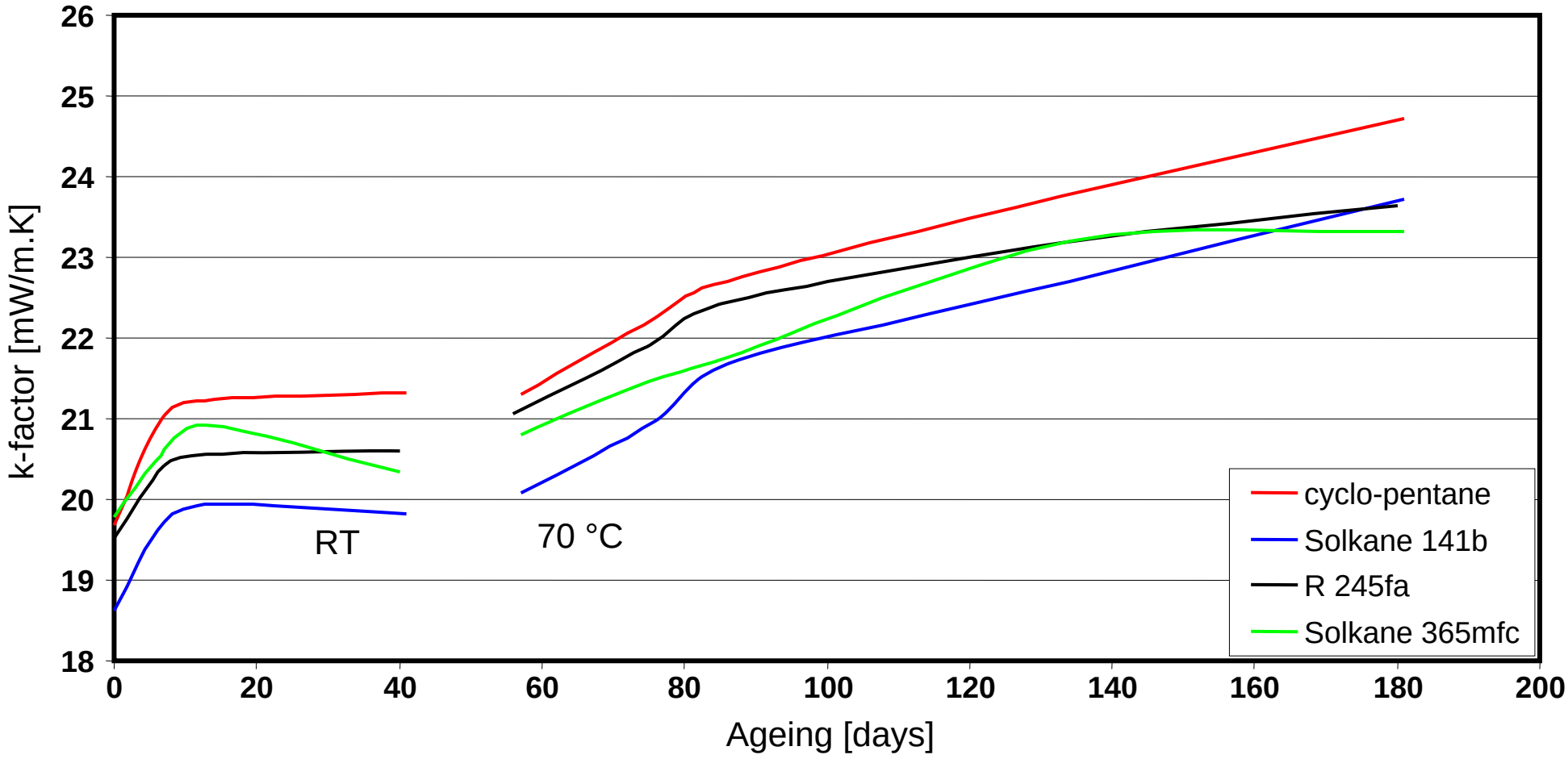
Flammability in Foams in Comparison

EN ISO 11925-2 – Ignitability Test (B2)



Ageing of foams in comparison

(measuring temperature 24 °C)



Solkane 365/227 (93:7)

Typical performance in application

Laminates

	HCFC-141b	HFC-365mfc	S 365mfc/ i-pentane	S 365mfc/ R 245fa	n-pentane
Lambda initial [mW/m.K, 10 °C]	18,6	19,5	19,8	19,1	22,5

Application	Construction Elements	Discont. Elements	Spray	Pour-In -Place
Density [kg/m^3]	39	32	62	49
Lambda initial [mW/m.K, 10 °C]	20	20,5	21	20,5

Best results in practise:

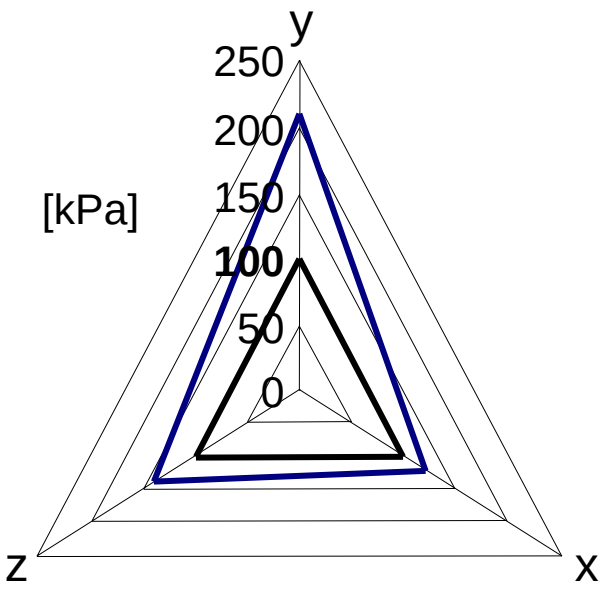
Object: cont. Panel

Facing: 50 µm Aluminium

Blowing Agent: Solkane 365/245 60:40

Core Density: 30 kg/m³

Cell Orientation:

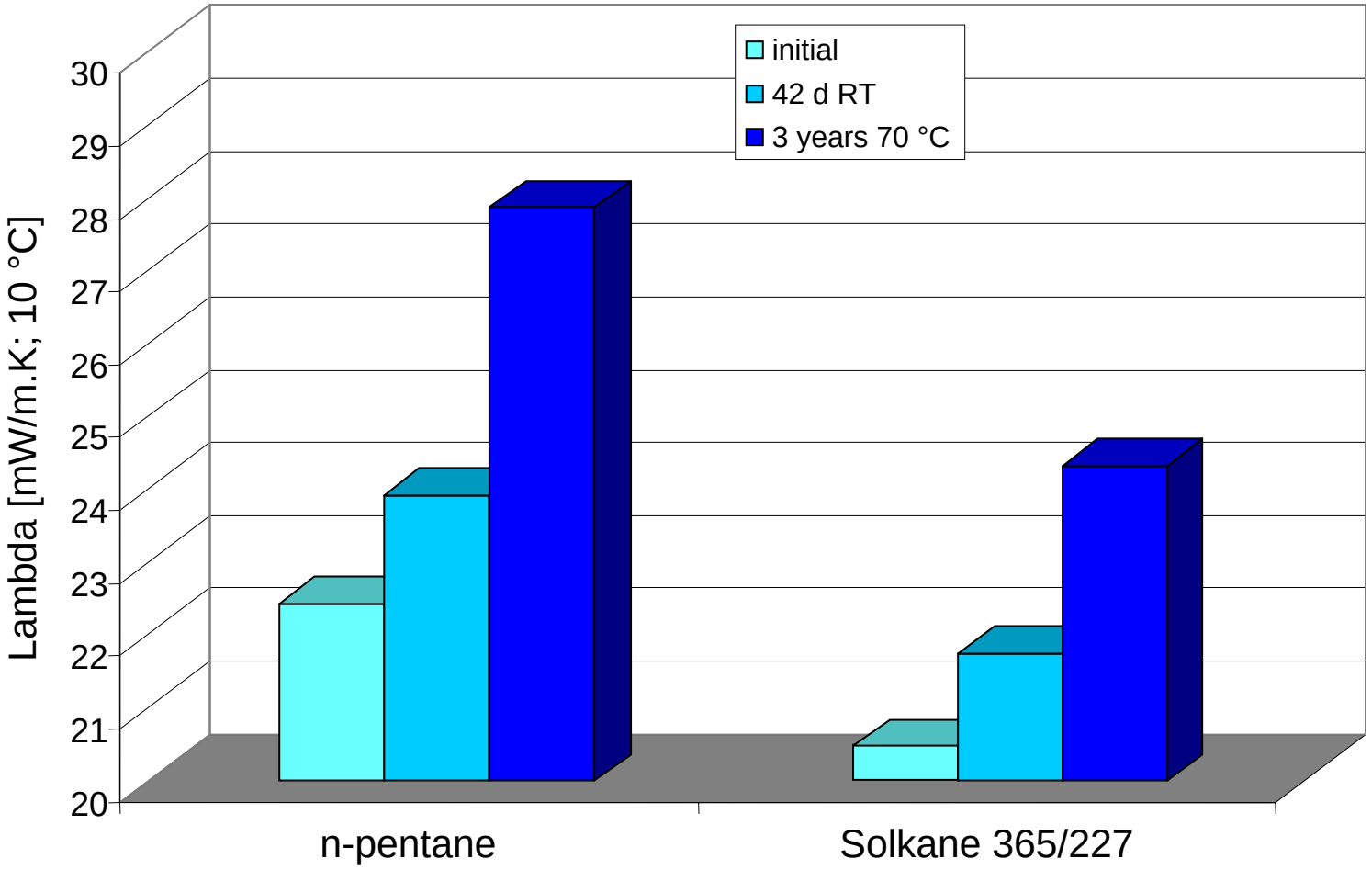


Lambda (10 °C; initial):

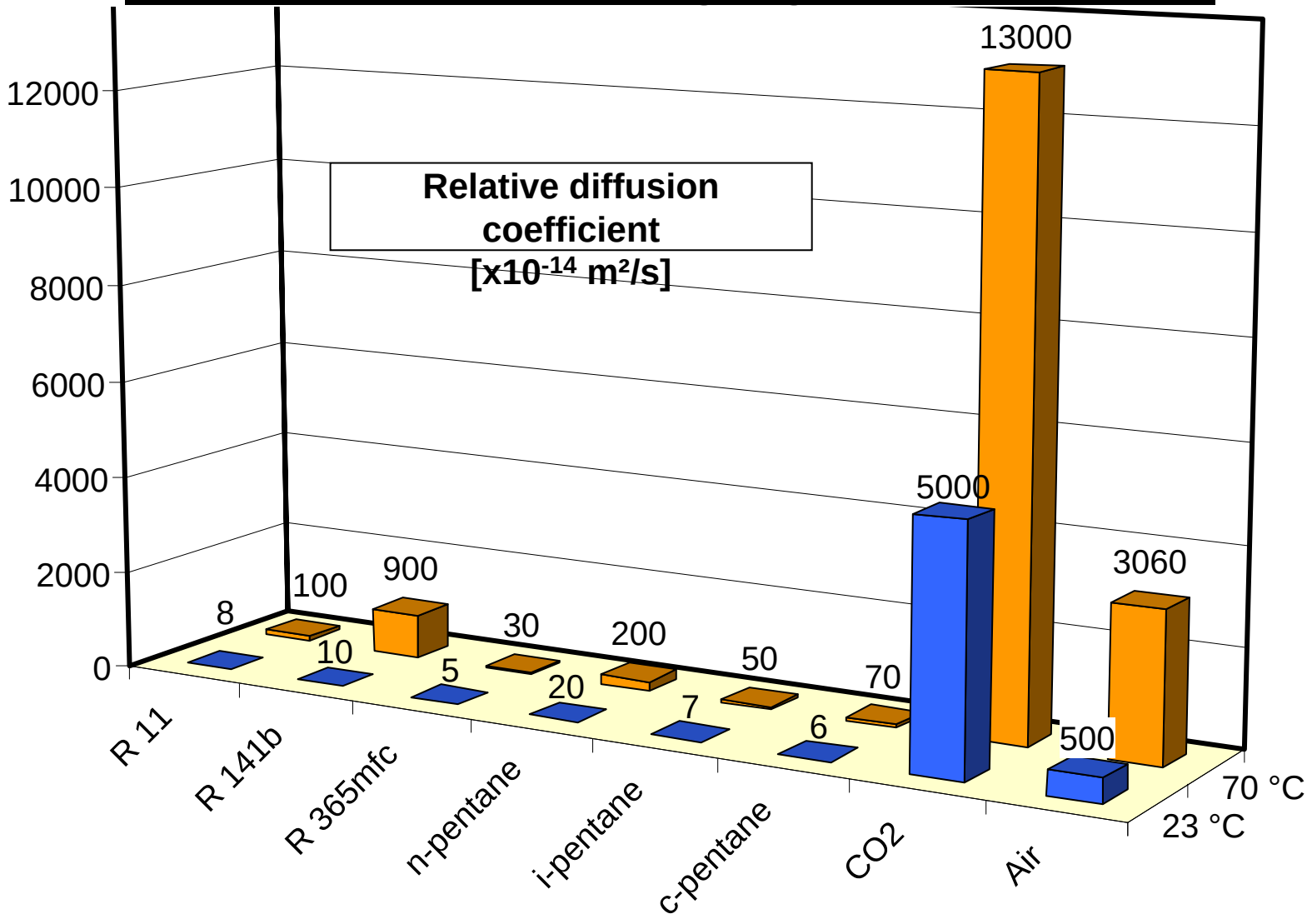
18.5 mW/m.K

Lambda Behaviour of Solkane 365mfc in Comparison

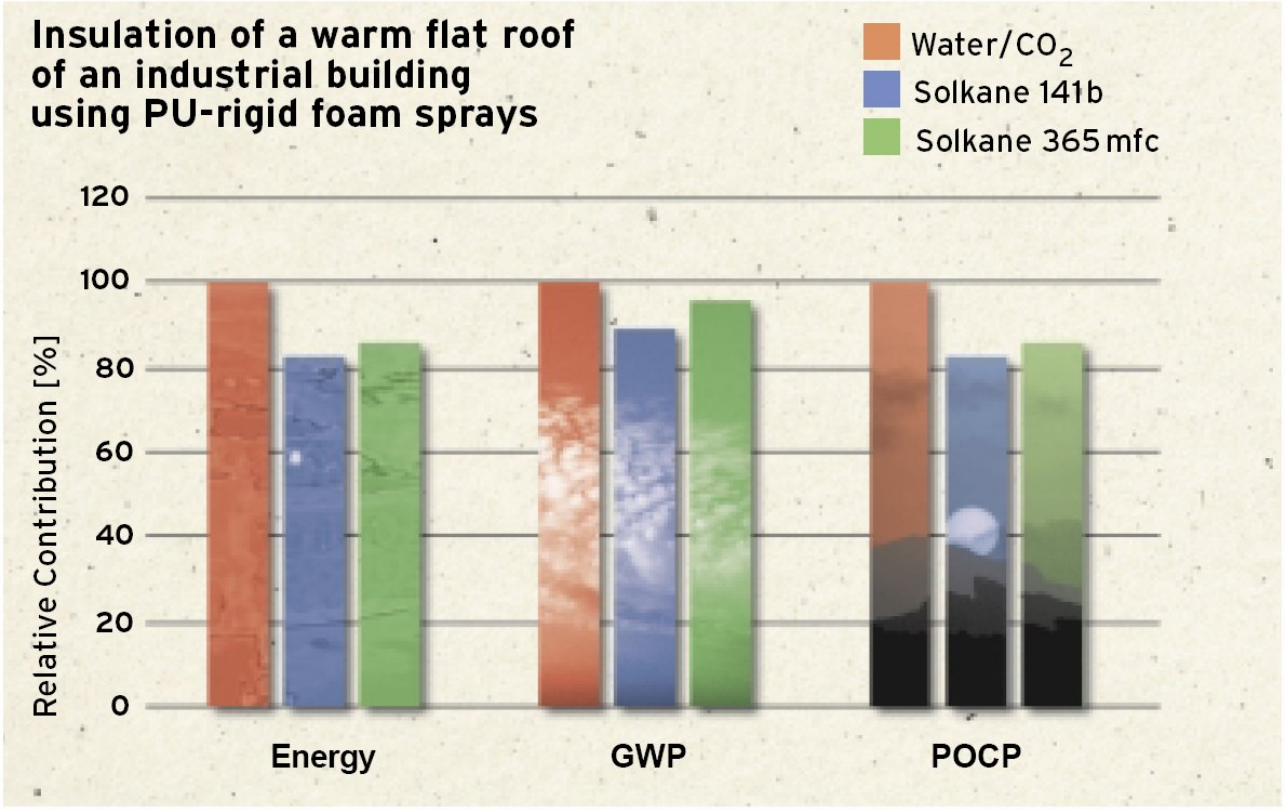
Long Term



Diffusion of blowing agents in foams



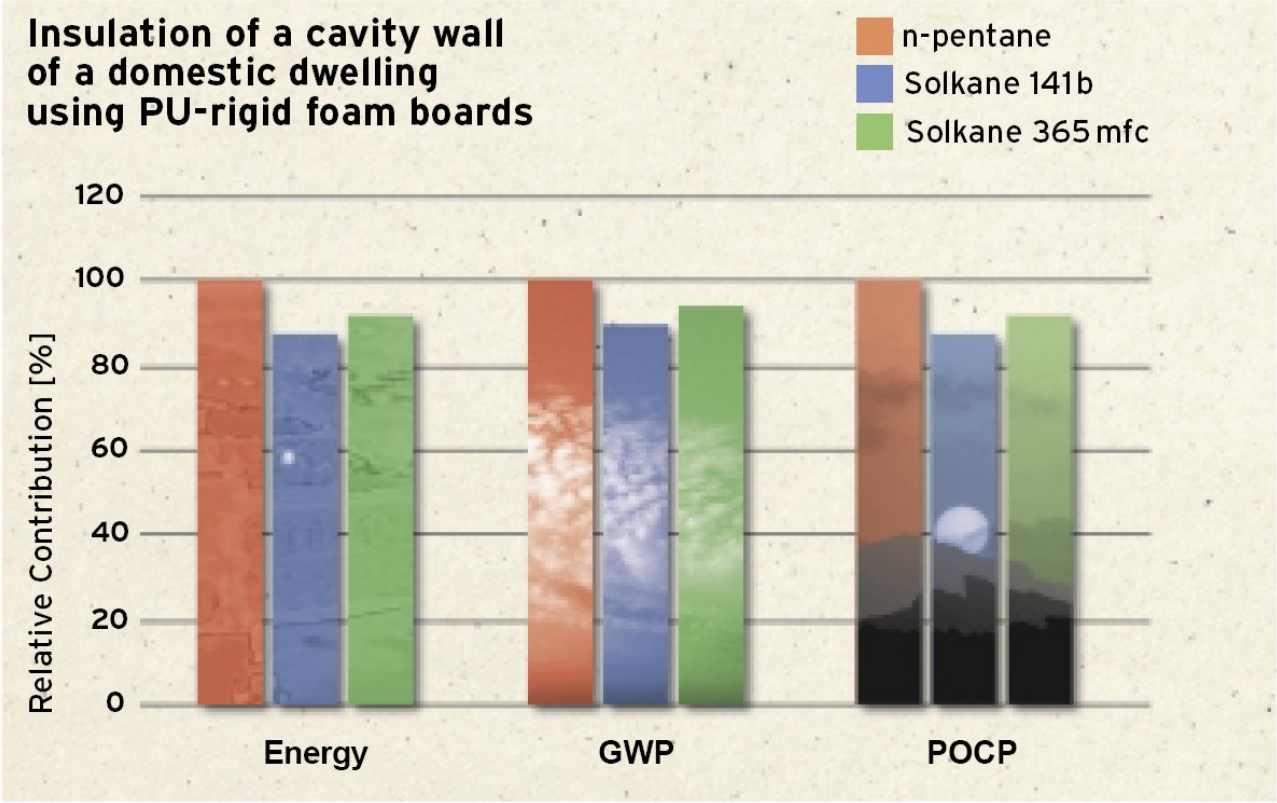
Life Cycle Environmental Profile of Water/CO2 vs HCFC-141b vs Solkane 365mfc



Partners:

Elastogran BASF Group · Kingspan INSULATION · Solvay Fluor und Derivate · Synthesia Española

Life Cycle Environmental Profile of n-Pentane vs HCFC-141b vs Solkane 365mfc



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Economic Spray foam
Advantage compared to Water blown Foams

	Water/CO_2	Solkane 365/227
Density [kg/m³]	> 40	30-33
Lambda (initial)	> 28	19-20
Fire behaviour	B 2	B 2
Foam behaviour	brittle	good
Adhesion	medium	good
Estimated price/m³	73 €	68 €

Better foam at lower price

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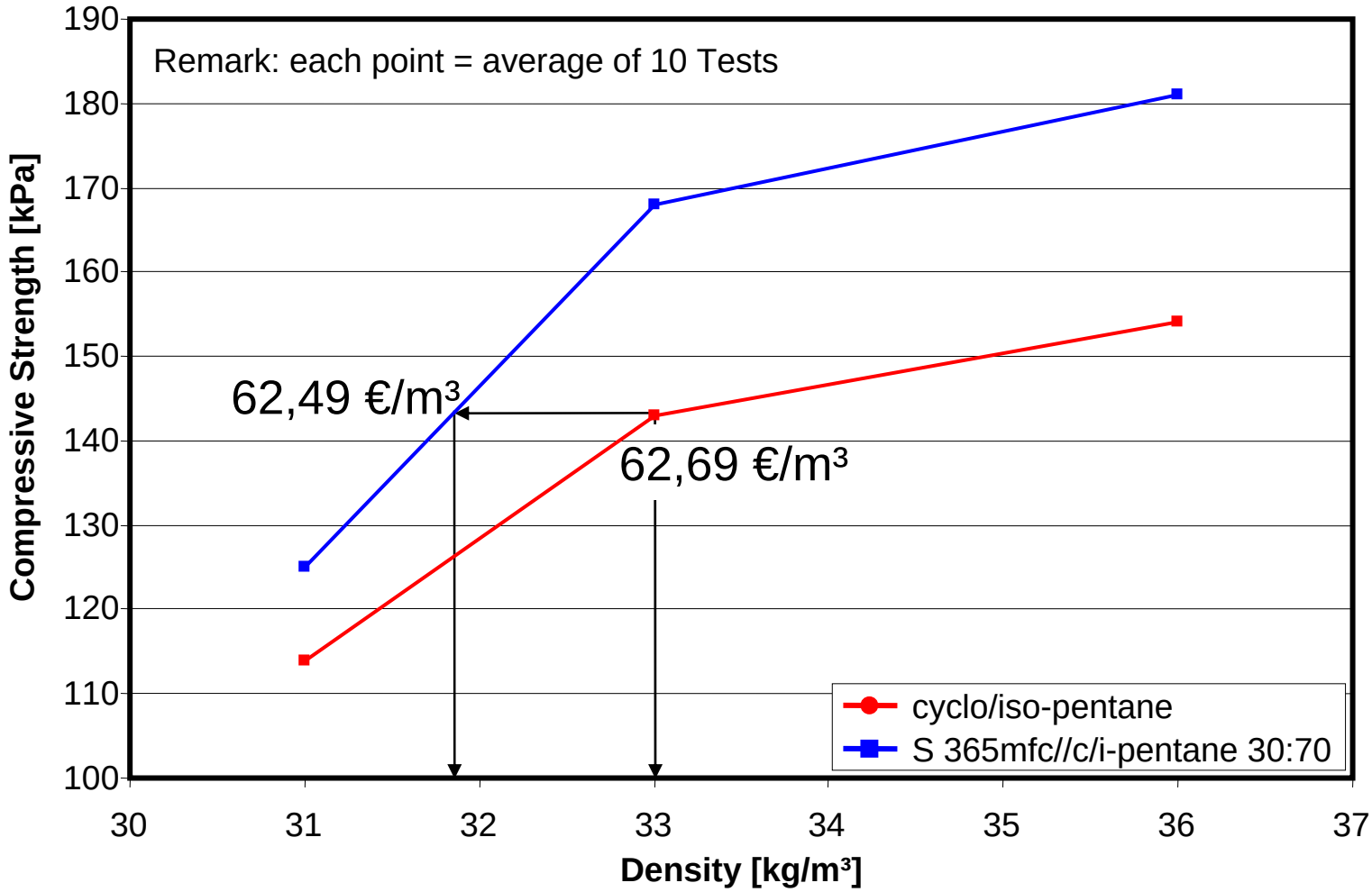
Reduction of Density



Cost evaluation per m³

PIR-system for continuous Steel Sandwich with n-Pentane

	Formulation		Costs	
	Standard	Co-Blowing	Standard	Co-Blowing
	[pbw]	[pbw]	[EURO/m³]	[EURO/m³]
Component A	82.5	69.3	29.92	28.08
Catalyst 1	3.0	2.5	1.63	1.52
Catalyst 2	0.9	0.6	0.82	0.61
n-Pentane	6.5		1.30	
S 365mfc/n-Pentane (30:70)		6.2		2.85
MDI	124	104	44.90	42.15
Sum	216.7	182.6	78.57	75.21
Density [kg/m³]	**39.3**	**37.0**	39.3	37.0
Comp. Strength [kPa]:	**120**	**129**		
Lambda [mW/m.K]:	**21.8**	**20.9**		
Difference				**-3.36 €/m³**

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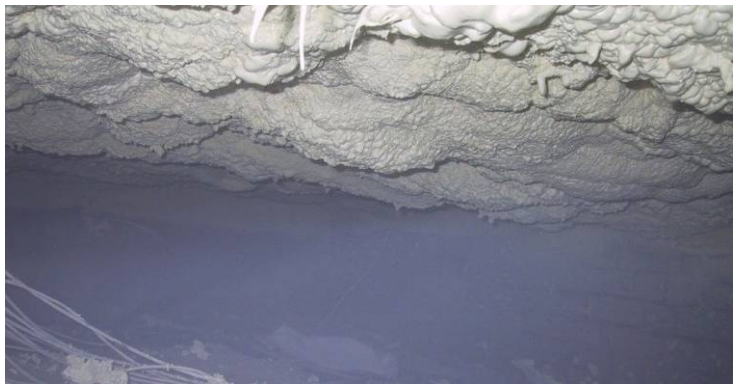
Easy and save handling
Spraying in closed rooms (cellar)

Classification	PUR, B 2
Core density [kg/m³]	32.3

Cell gases in foam [mass-%] after 6 days

Air	CO_2	R 227ea	R 365mfc
2.4	21.2	7.5	68.9

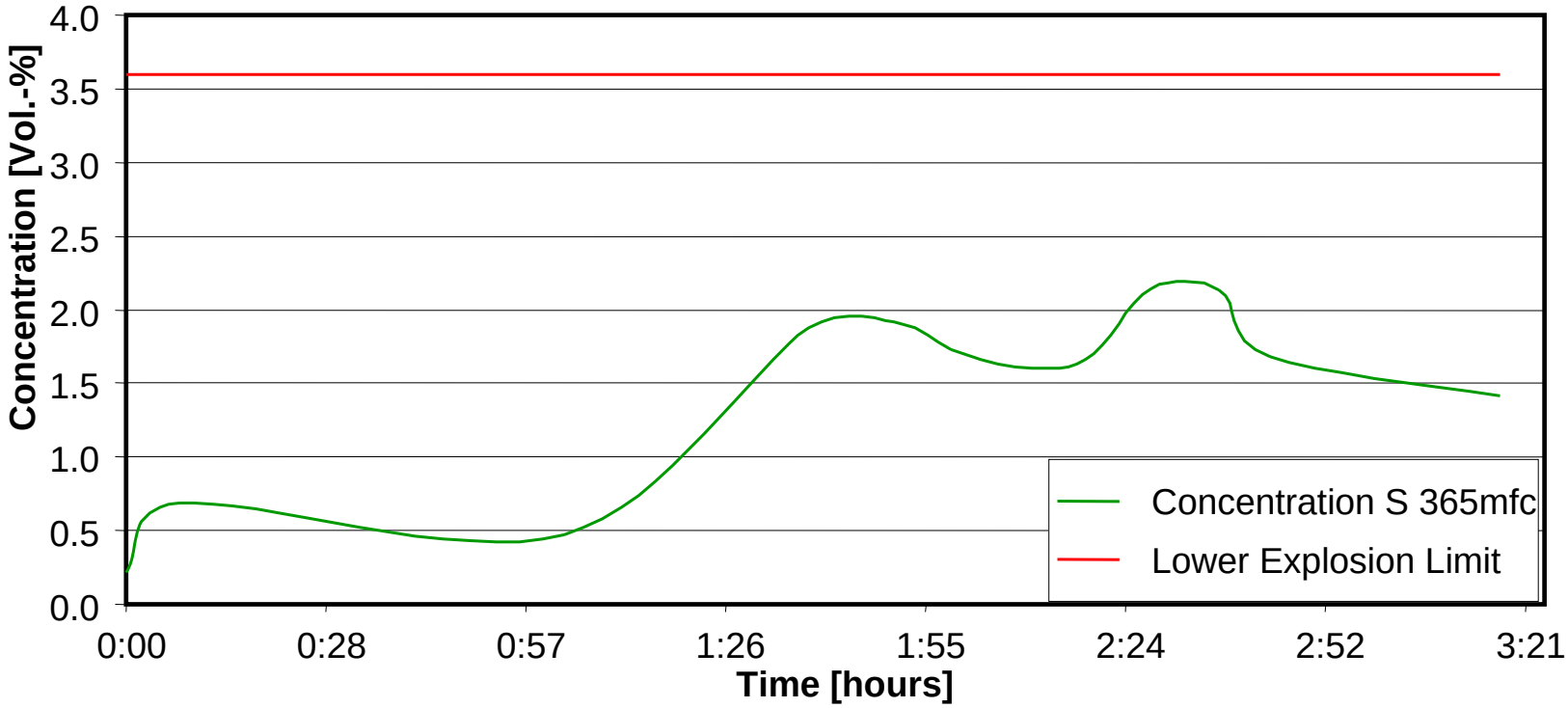
Compressive Strength	213 [kPa]
Lambda, initial	19.8 [mW/m.K]



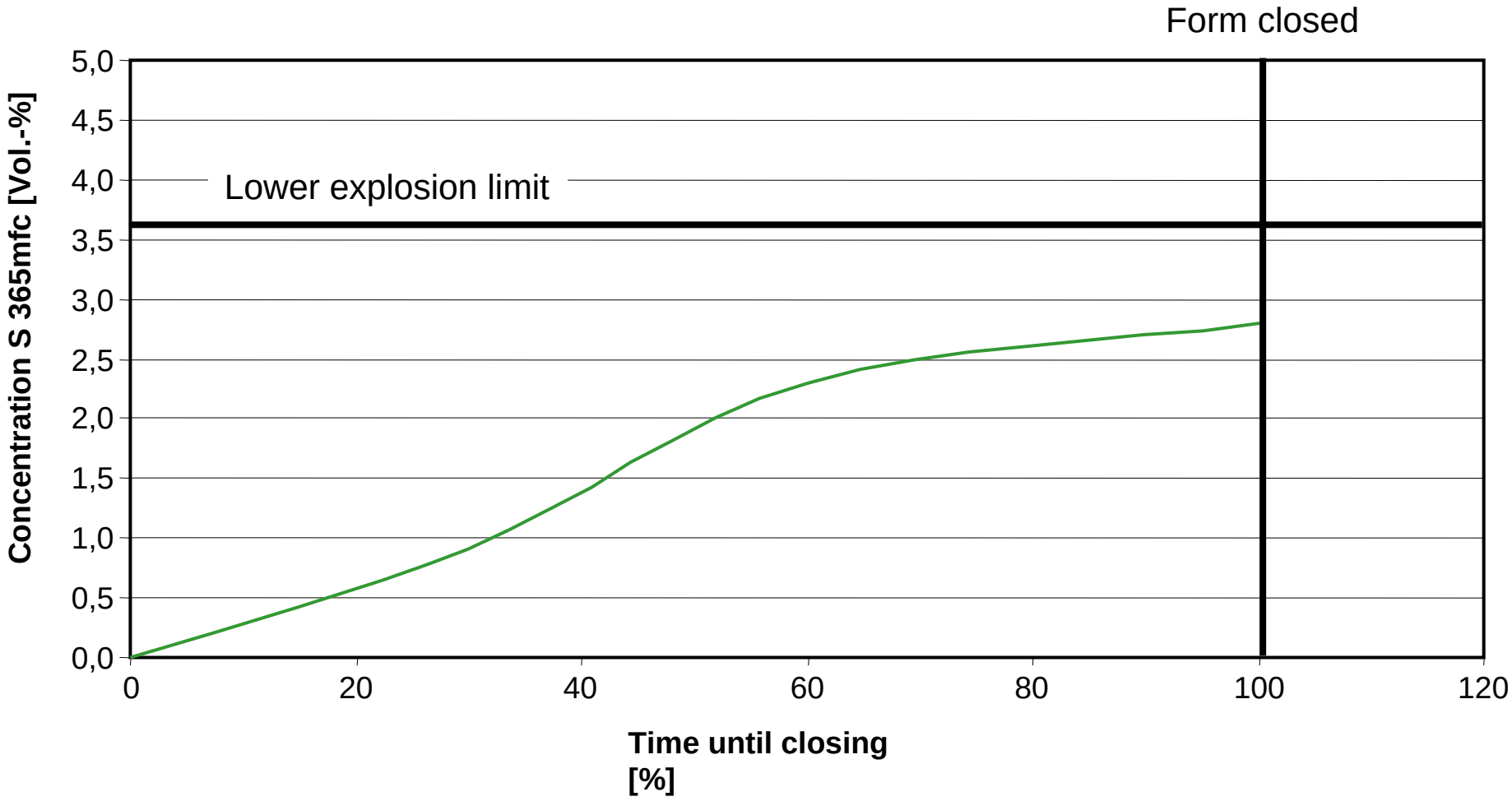
Emission of Solkane 365mfc during spraying

Dimensions:

Square area:	~60 m²	Height:	~70 cm
Opening (Top):	~70 x 70 cm	Foam thickness:	~20 cm



Emissions during a disk. Panel trial



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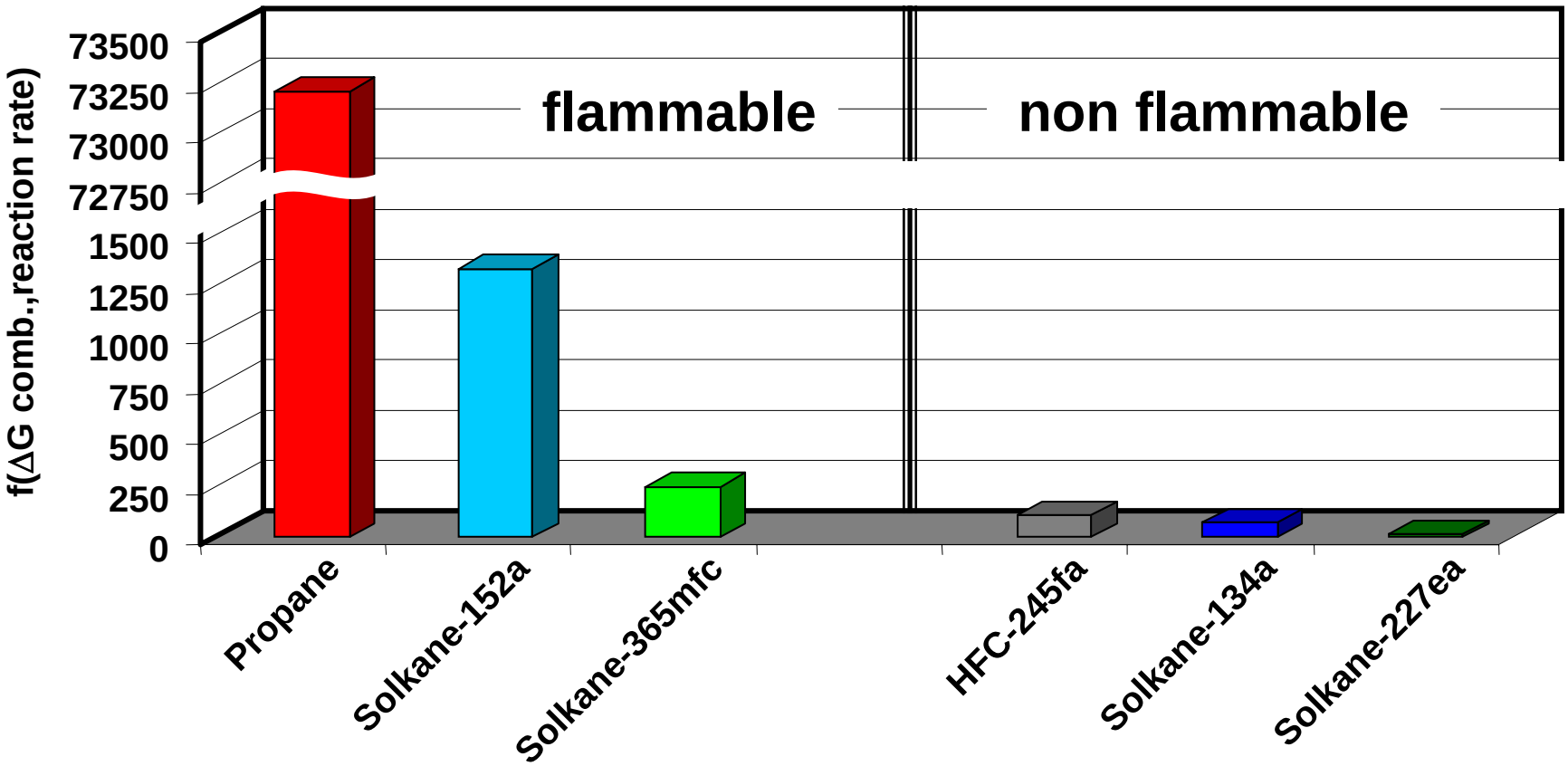
Flammability rating

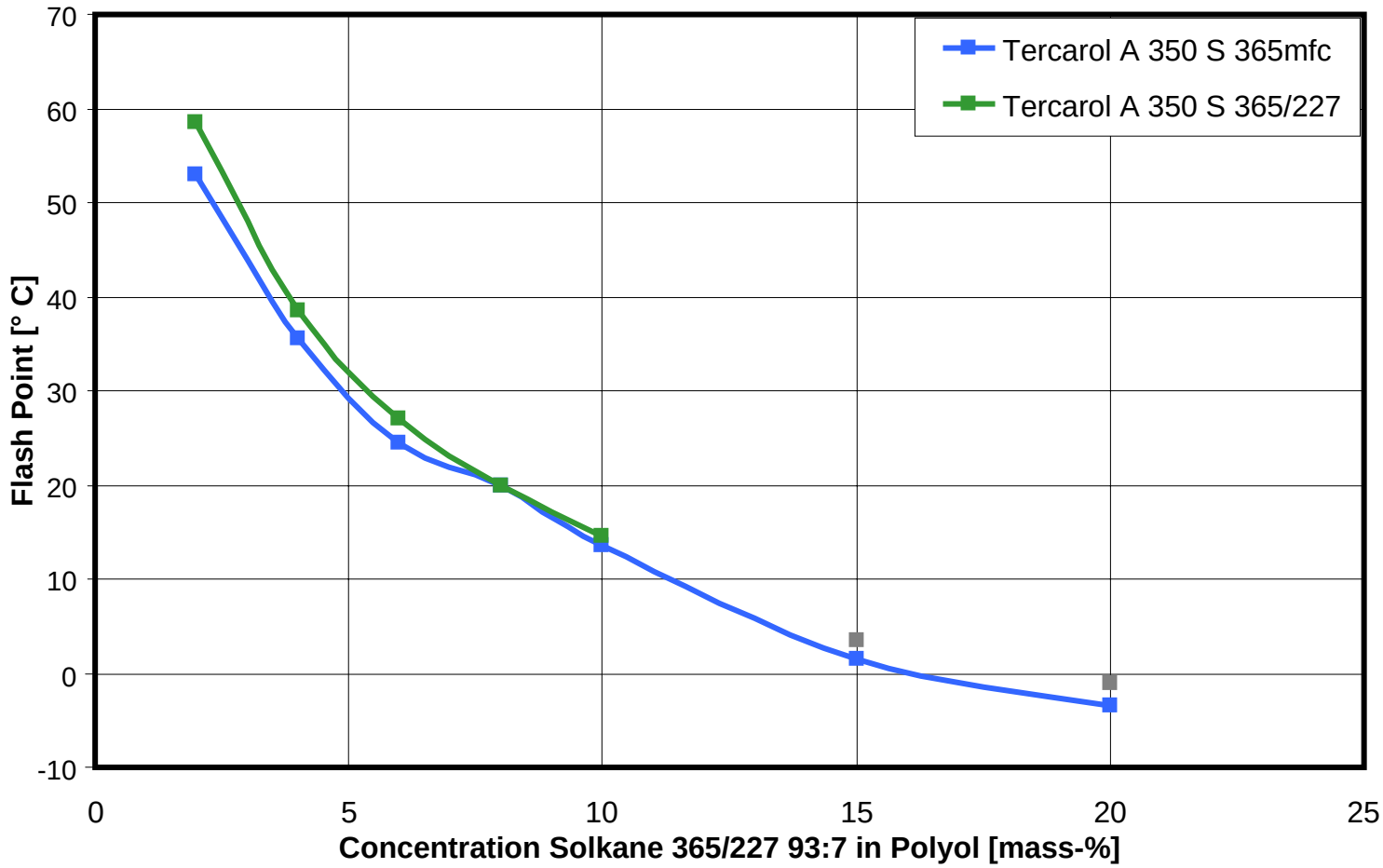
???????



Potential flammability suppressants for HFC-365mfc can be

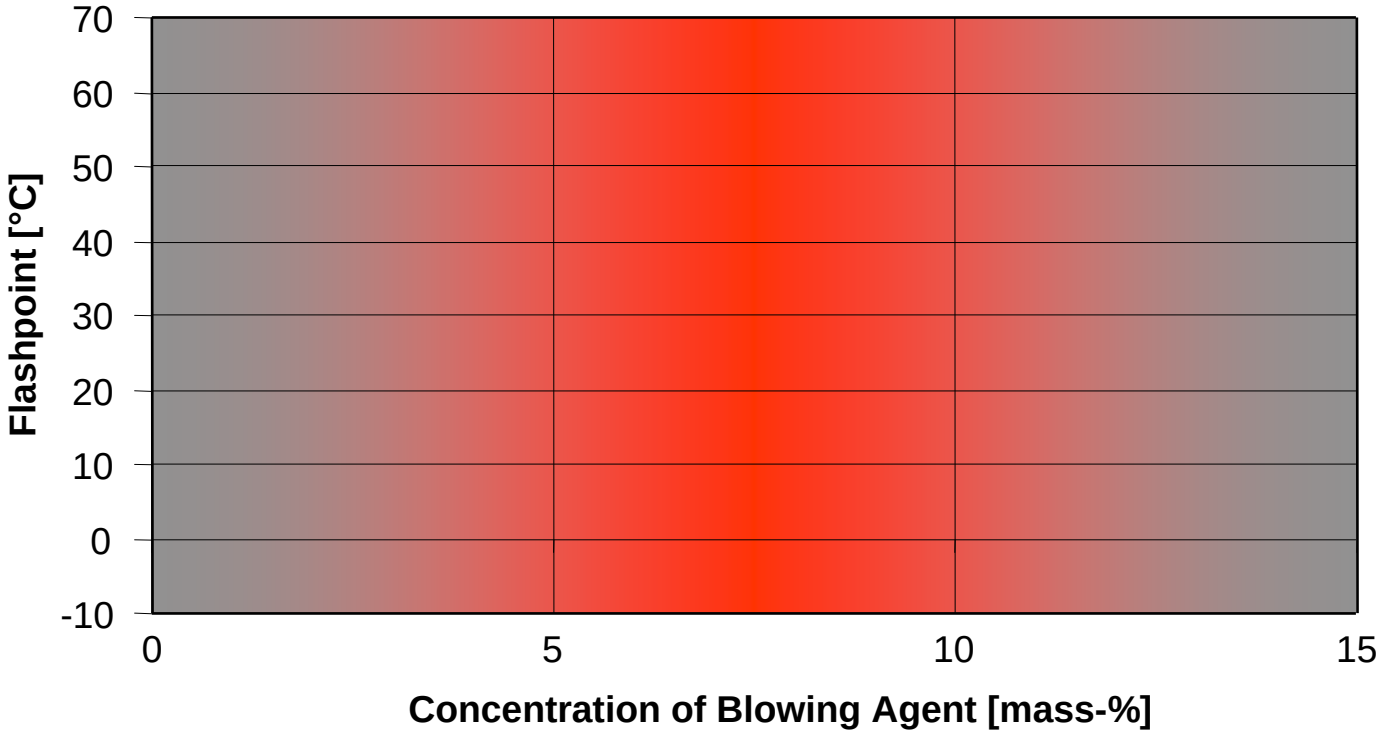
⇒ HFC-134a and HFC-227ea, HFC-245fa.

Evaluation of flashpoint as function of concentration



Evaluation of flashpoint as function of concentration of Solkane 365/227 – “flammable window”

Method: EN ISO 13736



Advantages of Solkane 365mfc

- working with a true liquid
- flammability in raw materials is solved
- best fire behaviour in foams of all physical foaming agents
- best insulation value of physical foaming agents including ageing of foam and thus implements the highest effect in saving CO_2 for the Environment
- low density foams with high dimension stability are standard and save costs