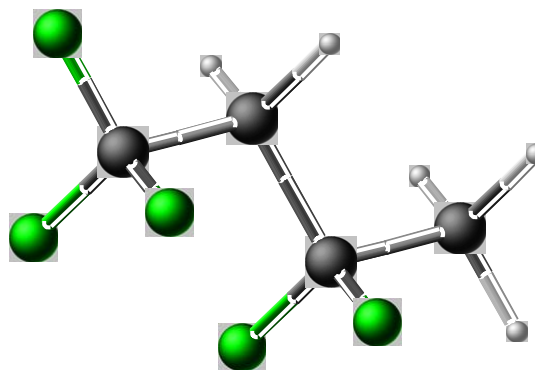


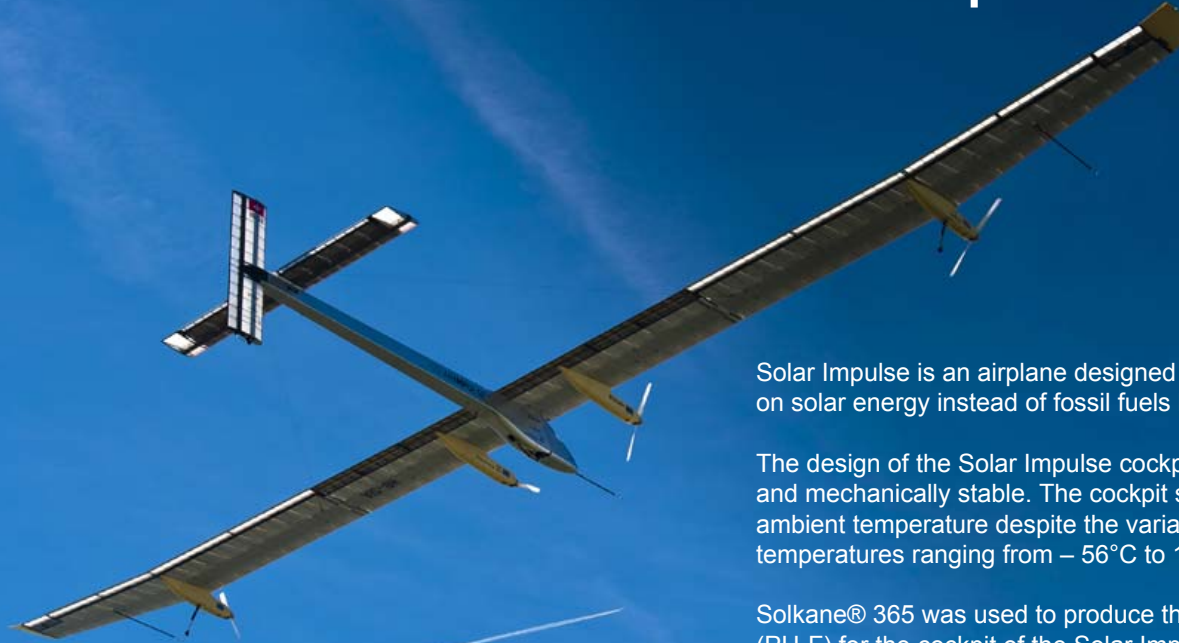
SOLKANE[®] 365 for Polyurethane Foam

Kris Schauvliege
Mario Avezu



© 2012, Solvay SA

Around the world with Solkane[®] 365: the perfect choice



Solar Impulse is an airplane designed to fly around the world on solar energy instead of fossil fuels by day and night.

The design of the Solar Impulse cockpit must be lightweight and mechanically stable. The cockpit should also conserve ambient temperature despite the variable outside temperatures ranging from -56°C to 130°C .

Solkane[®] 365 was used to produce the polyurethane foam (PU-F) for the cockpit of the Solar Impulse plane. The PU-F has the following outstanding properties:

- Best foam insulation values
- Best foam dimensional stability
- Best foam compressive strength

Case study: http://www.solvaychemicals.com/Chemicals%20Literature%20Documents/Fluor/HFC/SOLKANE_365_Case_Study_Solar_Impulse.pdf

SOLARIMPULSE | **SOLVAY**
AROUND THE WORLD IN A SOLAR AIRPLANE | MAIN PARTNER

Agenda

- SOLKANE[®] foaming agents
 - Properties
 - Safety and handling
 - Case studies
- Conclusion


SOLKANE[®] 365 & 365/227 foaming agents

- Easy and safe handling
 - SOLKANE[®] 365/227 is non-flammable as blend and in optimised systems
 - Available blends:
 - SOLKANE[®] 365/227 93:07 (recommended for foaming agent, direct use)
 - SOLKANE[®] 365/227 87:13 (recommended for foaming agent, systems)
- SOLKANE[®] 365 is flammable and can be used for co-blowing of pentane boards
- Performance and benefits
 - λ_{initial} : 19 – 20 mW/m K of PU-foams
 - GWP is compensated by (thermal) energy saving
 - Lower density PU than HCFC 141b and water blown foams

Physical properties

	HFC-365mfc	HFC-245fa	HFC-134a	HCFC-141b
Structure	$\text{CF}_3\text{-CH}_2\text{-CF}_2\text{-CH}_3$	$\text{CF}_3\text{-CH}_2\text{-CF}_2\text{H}$	$\text{CF}_3\text{-CFH}_2$	$\text{CCl}_2\text{F-CH}_3$
Mol.-Weight	148	134	102	116,9
Boiling Point [°C]	40,2	15,3	-26,1	31,7
Vapour pressure at 20 °C [bar]	0,4	1,2	5,7	0,6
λ [gas at 25 °C]	10,6	12,2	13,4	9,5
Flash point	-27	none	none	none
Flammability limits [% v/v]	3,6 - 13,3	none	none	7,4 - 17,7

Physical properties

	HFC-365mfc	n-pentane	i-pentane	c-pentane
Structure	$\text{CF}_3\text{-CH}_2\text{-CF}_2\text{-CH}_3$	$\text{CH}_3\text{-(CH}_2\text{)}_3\text{-CH}_3$	$\text{CH}_3\text{-CH(CH}_3\text{)-CH}_2\text{-CH}_3$	
Mol.-Weight	148	72	72	70
Boiling Point [°C]	40,2	36,1	27,8	49,5
Vapour pressure at 20 °C [bar]	0,4	0,6	0,8	0,35
λ [gas at 25 °C]	10,6	15,2	14,7	12,0
Flash point [°C]	-27	-49	-57	-37
Flammability limits [% v/v]	3,6 - 13,3	1,4 - 7,8	1,4 - 8,3	1,4 - 8,3

Physical properties

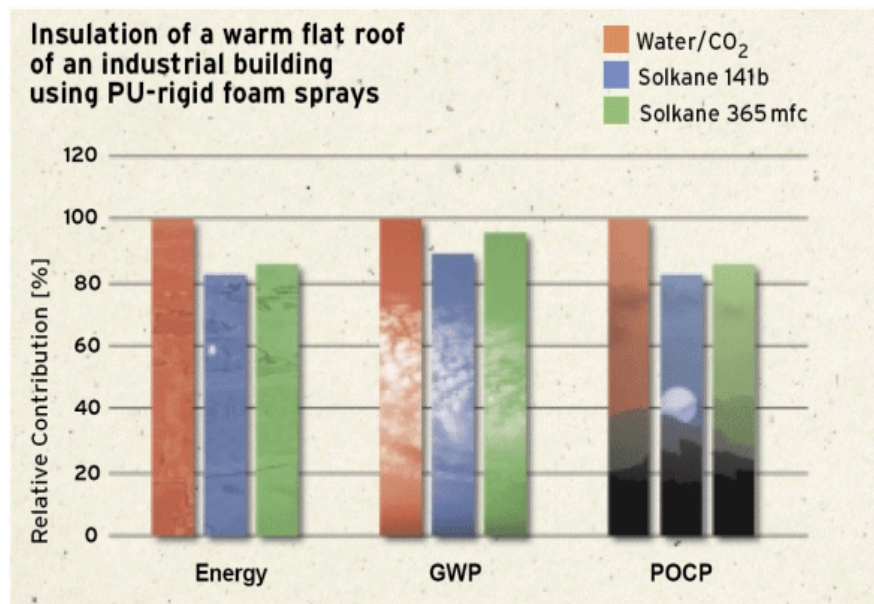
	HFC-365mfc	Dimethoxymethane (Methylal)	Methylmethanoate (Methyl formate)
Structure	$\text{CF}_3\text{-CH}_2\text{-CF}_2\text{-CH}_3$	$\text{CH}_3\text{-O-CH}_2\text{-O-CH}_3$	CH_3OOCH
Mol.-Weight	148	76	60
Boiling Point [°C]	40,2	41	32
Vapour pressure at 20 °C [bar]	0,4	0,44	0,58
λ [gas at 25 °C]	10,6	13,1	10,7
Flash point [°C]	-27	-18	-32
Flammability limits [% v/v]	3,6 - 13,3	2,2 – 19,9	5 - 23

Physical and ecological properties

	HFC-365mfc	HFC-245fa	n-Pentane	c-Pentane	Methylal	Methylformate	HCFC-141b
Boiling Point [°C]	40.2	15.3	36.1	49.5	41	32	31.7
Atm. Lifetime [years, IPCC 4, 2007]	8.6	7.6	5 days	"few days"	"few days"	20 days	9.3
ODP	0	0	0	0	0	0	0,11
GWP [IPCC 4, 2007]	794	1030	3-7	11	negligible	~ 1	725
VOC	no	no	yes	yes	yes	no	no

Why SOLKANE® 365 for Spray Foam?

- Life cycle assessments (LCA) of Spray Foam insulation show a benefit for the environment because of energy savings even compared with low-GWP products.
- We deduced from the LCA that 1 kg SOLKANE® 365 saves 1000 kg CO₂ considering the life time of PU-rigid foam sprays.

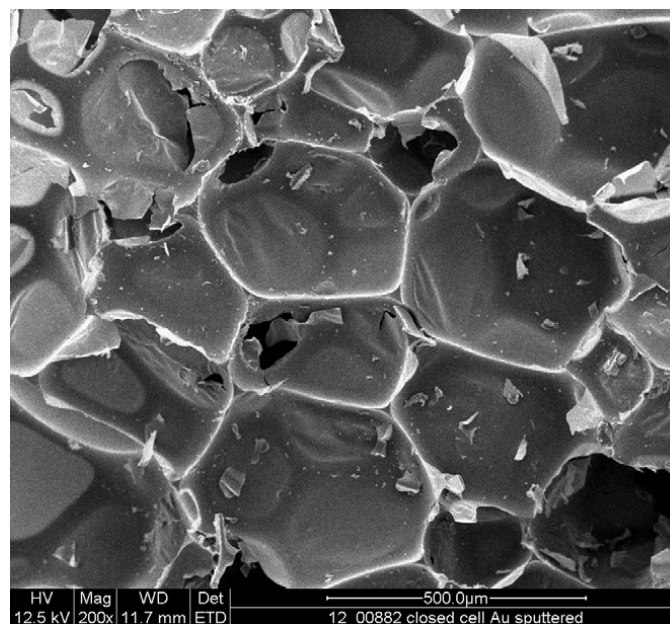
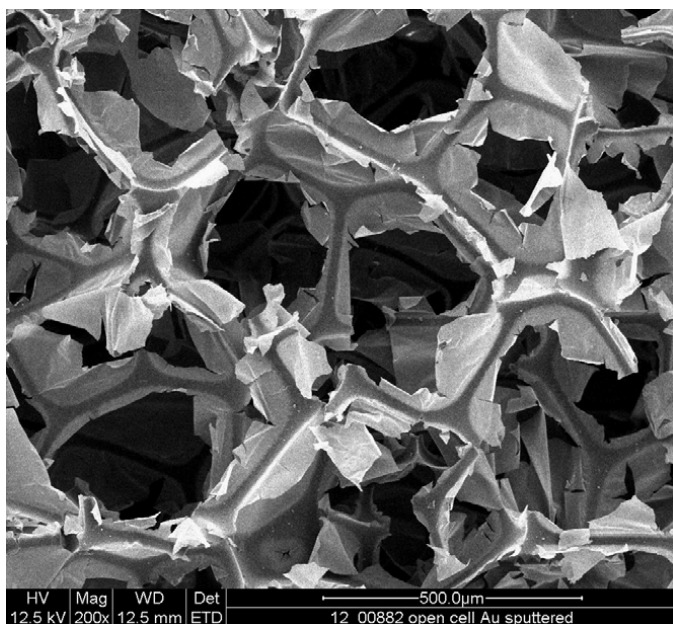


From: "HFC-365mfc and high performance rigid polyurethane insulation";
 Elastogran, Kingspan, Solvay, Synthesia, 2000

http://www.solvaychemicals.com/Chemicals%20Literature%20Documents/Fluor/HFC/LCA_HFC_365mfc_blown_pu_insulation_sprays_EN.pdf

© 2012, Solvay SA

Open and closed cell PU foams



Open cell (left) and closed cell (right) PU foams

Open and closed cell PU foams

Parameter	Open cell	Closed cell
	Water blown	SOLKANE® 365/227 blown
Thermal conductivity λ , initial (mW / m K)	25	19
Thermal conductivity λ , aged (mW / m K)	35	25
Density (kg / m ³)	8	32 medium 48 high
Permeability	High	Low
Air Barrier	Y	Y
Water absorption	Y	N
Others	Good sound barrier	Good thermal insulation

Agenda

- SOLKANE[®] foaming agents
 - Properties
 - Safety and handling
 - Case studies
- Conclusion

Emissions during a Foam Spray trial

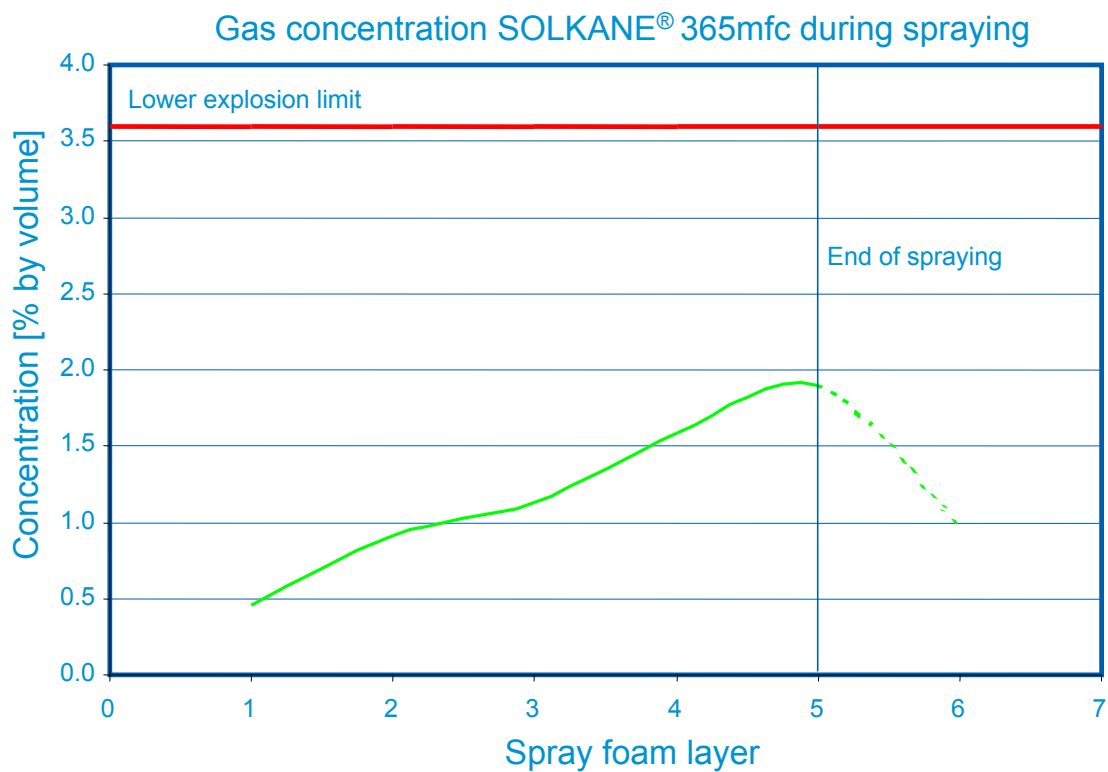
Box dimensions:
80 x 120 x 120 cm

Average foam thickness
after spraying:
15 cm (12,5 % v/v)



© 2012, Solvay SA

Emissions during a Foam Spray trial



© 2012, Solvay SA

SOLKANE[®] 365/227 for cellar roof insulation

Dimensions:

Square area:	~60 m ²
Height:	~70 cm
Opening (Top):	~70 x 70 cm
Foam thickness:	~20 cm

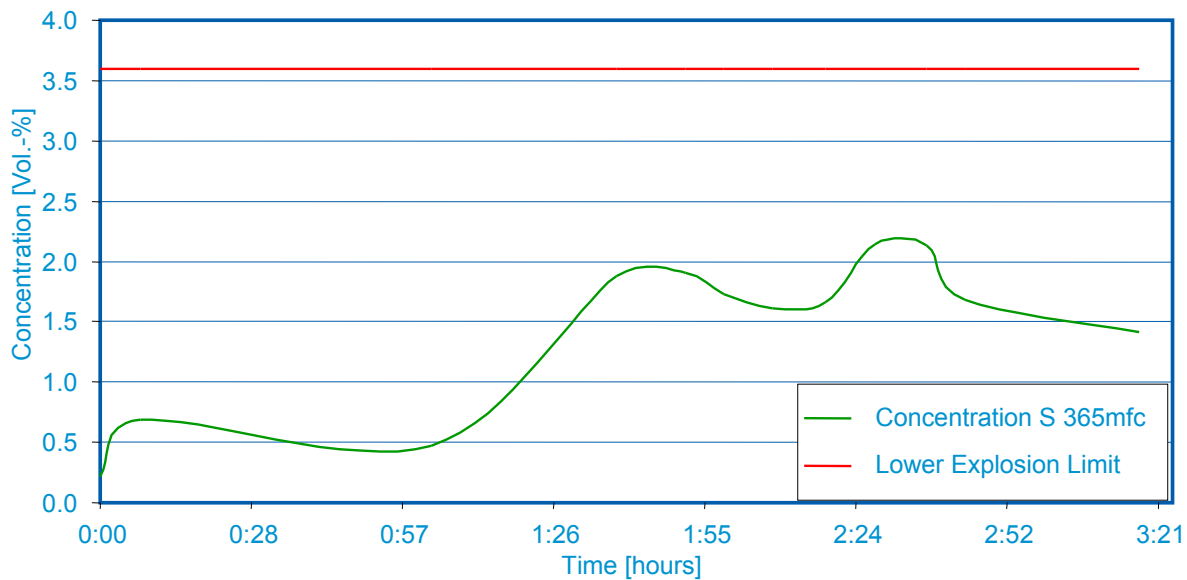
Classification:	PUR
Fire class:	B
Core density [kg/m ³]:	32.3
Compressive Strength [kPa]:	213
λ , initial [mW/m.K]:	19.8



SOLKANE® 365/227 for cellar roof

Cell gases in Foam [% m/m] after 6 days

Air	CO2	R 227ea	R 365mfc
2.4	21.2	7.5	68.9

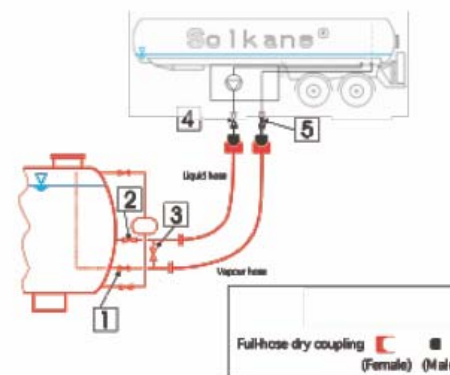


© 2012, Solvay SA

Transport Packaging Storage

- **Unloading: dry disconnect coupling**
- **Closed loop:**
 - Liquid filling line
 - Gas phase line

Parameter	Unit	SOLKANE® 365mfc	SOLKANE® 365/227 93/07	SOLKANE® 365/227 87/13
Specific gravity (at 20 °C)	kg / dm ³	1.27	1.28	1.29
Pressure (at 20 °C)	bar	0.43	0.69	0.88
Pressure (at 50 °C)	bar	1.38	1.91	2.32



During Delivery - emission free dry coupling parts are connected

© 2012, Solvay SA

http://www.solvaychemicals.com/Chemicals%20Literature%20Documents/Fluor/HFC/Tech_Solkane_Ixol_Foaming_Agents_Transport_Pack_EN.pdf

Agenda

- SOLKANE® foaming agents
 - Properties
 - Safety and handling
 - Case studies
- Conclusion

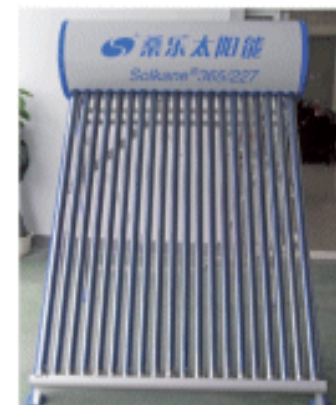
Co-blowing – Household appliances

Refrigerator type	Normal type	Energy saving type	Three-door type
cPentane blowing agent	0.410 kWh/24h	0.398 kWh/24h	0.665 kWh/24h
Multi-Co-blowing system (SOLKANE® 365)	0.370 kWh/24h	0.356 kWh/24h	0.600 kWh/24h
Energy Consumption	- 10 %	- 11 %	- 10 %

Co-blowing: Solar Water Heater

HCFC-141b HFC-365mfc c-Pentane

Overall Density	55	47	52	[kg/m ³]
Core density	42	38	37	[kg/m ³]
Comp.-Strength	168	171	161	[kPa]
λ at 23 °C	19.1	20.5	22.8	[mW/m K]



© 2012, Solvay SA

http://www.solvaychemicals.com/Chemicals%20Literature%20Documents/Fluor/HFC/SOLKANE_365_Case_Study_Solar_Water_Heater.pdf

LNG Storage Tank Insulation

Liquefied natural gas is cooled down to -162 °C and shipped in LNG Tankers,

	HCFC-141b			SOLKANE 365		
	Top	Wall	Bottom	Top	Wall	Bottom
Density [kg/m ³]	42	84	118	41.5	82.7	110
Compressive Strength						
Required	170	530	870	170	530	870
Result	270	770	1280	340	840	1330
Comp.-Strength cryo.						
Required	220	690	1230	220	690	1230
Result	530	1690	2520	840	1130	1950
λ at 25 °C (mW/m K)						
Required	21.3	22.9	25.1	21.3	22.9	25.1
Result	20.8	22.2	23.8	21.0	22.5	24.4



© 2012, Solvay SA

http://www.solvaychemicals.com/Chemicals%20Literature%20Documents/Fluor/HFC/SOLKANE_365_Case_Study_Reefer_Container.pdf

Spray foam on a roof (outside) insulation in Czech Republic



Spray Foam is the typical application for non-flammable Blowing Agents such as SOLKANE[®] 365/227.

Due to the good properties Spray Foam is the most effective, the easiest, the fastest and often the cheapest solution of insulation for most of the buildings or houses. Better thermal insulation saves energy and reduce CO₂ emissions. Note: it also offers a benefit to repair the surface of damaged roofs.

Conclusion

- SOLKANE® Blowing Agents for Spray Foams
 - Liquid
 - Safe handling
 - Suitable for new and old buildings
 - Fast to implement
 - Cost effective
 - Good Adhesion
 - Best performance
 - λ initial
 - λ aged
 - Energy savings
 - High dimensional stability
 - Fire class

Thank you

- All statements, information, and data given herein are believed to be accurate and reliable but are presented without guarantee, warranty or responsibility of any kind, express or implied. Statements or suggestions concerning possible use of our products are made without representation or warranty that any such use is free of patent infringement, and are not recommendations to infringe any patent. The user should not assume that all safety measures are indicated, or that other measures may not be required. In any case, the user is not exempt from observing all legal, administrative and regulatory procedures relating to the product, personal hygiene, and protection of human welfare and the environment.
- All statements or suggestions concerning the possible uses of HFC's and blends thereof are made without any representations and/or warranties whatsoever that any such use is free of legal constraints.
- In particular, the use of Solkane® 365mfc and of blends containing Solkane® 365mfc might fall within the scope of European Patent 381 986 and its counterparts. Solvay has acquired certain rights from Bayer under these patents, according to which Bayer has agreed not to assert any of such patent rights against any purchaser of Solkane® 365mfc and blends containing Solkane® 365mfc from Solvay for use as foam blowing agent outside the USA.
- The following must be noted regarding the USA: (1) Solkane® 365mfc cannot be used in the USA by itself or in a blend, as a blowing agent to foam a plastic based on an Isocyanat to form plastic foam compositions; (2) Solkane® 365mfc and blends containing Solkane® 365mfc must not be made, used, offered for sale, or sold in the USA or imported into the USA for such blowing uses; and (3) closed cell plastic foam compositions prepared by foaming a plastic material based on Isocyanat in the presence of a propellant comprising Solkane® 365mfc and/or a blend containing Solkane® 365mfc, cannot be made, used, offered for sale, or sold, within the USA or imported into the USA. To do so can result in a claim of patent infringement under U.S. patent no. 5,496,866. Solvay will not sell Solkane® 365mfc or blends containing Solkane® 365mfc to any purchaser intending to use the product accordingly.
- Brochures and case studies are online available:
http://www.solvaychemicals.com/EN/products/Fluor/Construction_Industry-Thermal_insulation.aspx



a Passion for Progress®