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ZHROC
上海 闵行

Alternatives for HCFC-141b

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Self Introduction

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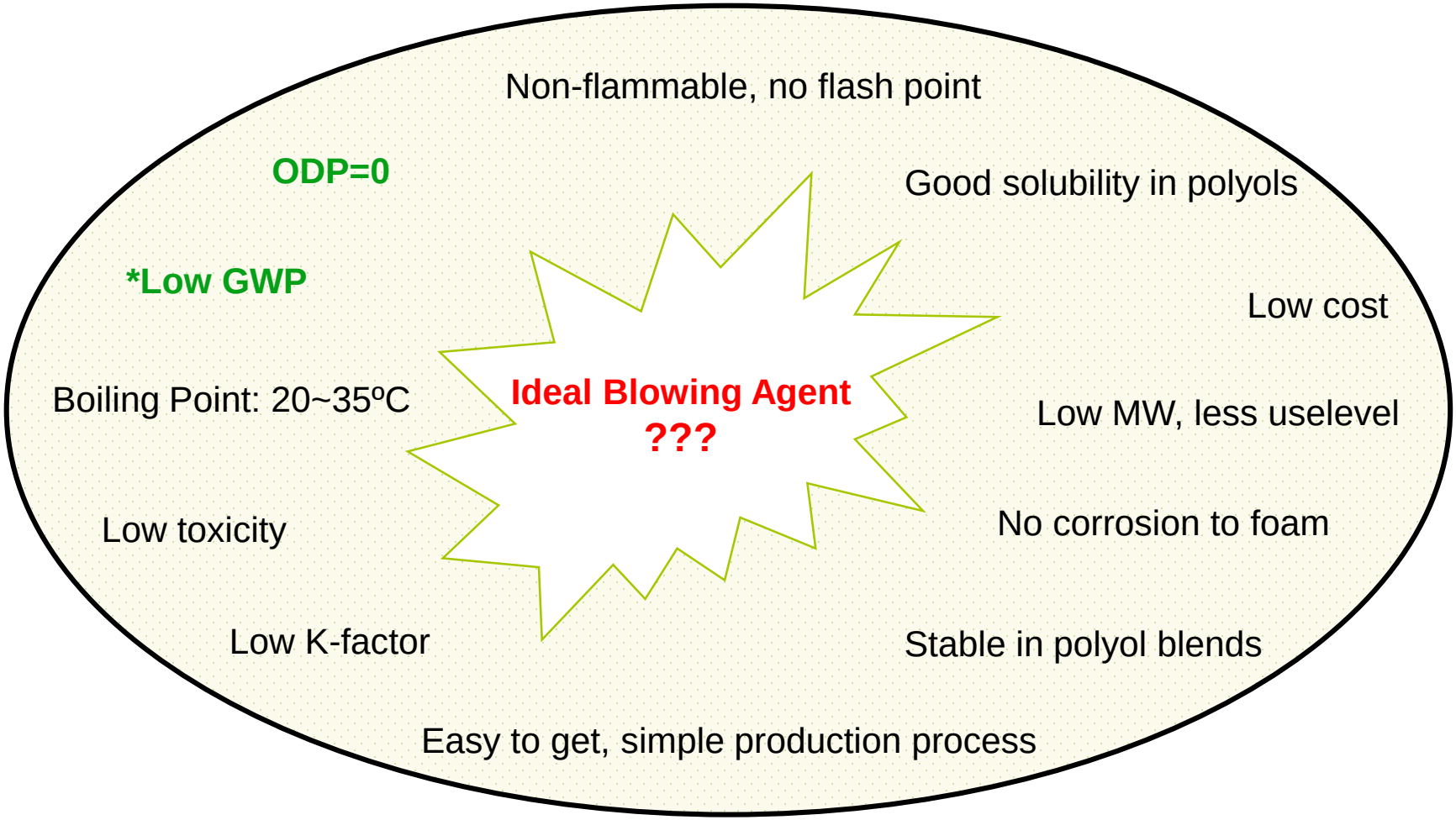
Downstream — Polyurethane Industry (22 years) — Upstream

	Downstream	Polyol/PU system Industry	PU additive industry: Silicone/catalyst
1996.9-1999.12	西浴冰箱 Serene Serene/appliance		
2000.1-2002.6	Appliance Industry: Refrigerator, freezer	AGC Ashai Glass/Shanghai	
2002.7-2005.12		BAYER Asia R&D Center	
2006.1-2007.6			AIR PRODUCTS Asia R&D Center
2007.7-2012.12		BASF The Chemical Company Asia R&D Center	
2013.1-2014.8		YB YOBO POLYURETHANE R&D Center	

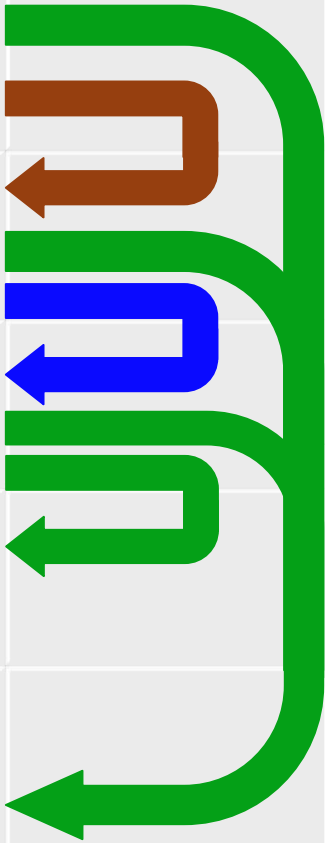
Ideal Blowing Agent???



*: GWP: Need to consider CO_2 emission in the process of making the blowing agent

PU Blowing Agents Development Trend

	TYPE	TYPICAL SUBSTANCE	ODP	GWP	ROUTE
1st Gen	CFCs	CFC-11	1.0	1100	
2nd Gen	HCFCs	HCFC-141b	0.11	725	
3rd Gen	HFCs	HFC-245fa HFC-365mfc	0 0	1030 794	
4th Gen	H(C)FOs	HCFO-1233zd HFO-1336mzz	~0 0	1 8.9	
…. Final solutions	Hydrocarbon Water/CO_2	c-Pentane Water	0 0	<25 1	



Available Alternatives

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Part-1: Hydrocarbons & Water

Substance	*HCFC141b	*c-Pentane	*n-Pentane	*i-Pentane	*i-Butane	Water
Structure	CH_3CCl_2F	C_5H_{10}	C_5H_{12}	C_5H_{12}	C_4H_{10}	CO_2
MW	117	70.1	72.2	72.2	58.1	44.0
Boiling point (ºC)	31.9	49	36.1	28.0	-11.7	-79
Flash point (ºC)	None	-42	-49	-57	-107	None
Explosion limit (vol% in air)	5.6~17.7	1.5~8.7	1.4~8.0	1.4~8.3	1.8~8.4	None
ODP (CFC11=1)	0.11	0	0	0	0	0
GWP (CO_2=1)	725	<25	<25	<25	<25	1
λ[mW/(m•K)]	9.7 (25ºC)	11.0 (10ºC)	14.0 (10°C)	13.0 (10°C)	15.9 (20°C)	16.3

*: Data from UNEP-FTOC Report 2010

Available Alternatives

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Part-2: HFCs (Will be phased out in the future)

Substance	*HFC245fa	*HFC365mfc	*HFC134a	*HFC227ea	*HCFC141b
Structure	$CF_3CH_2CHF_2$	$CF_3CH_2CF_2CH_3$	CH_2FCF_3	CF_3CHFCF_3	CH_3CCl_2F
MW	134	148	102	170	117
Boiling point (ºC)	15.3	40.2	-26.2	-16.5	31.9
Flash point (ºC)	None	<-27	-79	None	None
Explosion limit (vol% in air)	None	3.6~13.3	None	None	5.6~17.7
ODP (CFC11=1)	0	0	0	0	0.11
GWP (CO_2=1)	1030	794	1430	3220	725
λ[mW/(m•K)]	12.1 (20ºC)	10.6 (25ºC)	13.7 (25°C)	12.7 (25°C)	9.7 (25ºC)

*: Data from UNEP-FTOC Report 2010

Available Alternatives

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Part-2: Others (Not popular)

Substance	*ECOMATE	HFE 254	Methylal	*TDCE	*HCFC141b
Structure	$HCOOCH_3$	$HCF_2CF_2OCH_3$	$CH_3OCH_2OCH_3$	CHCl=CHCl	CH_3CCl_2F
MW	60	132	76	97	117
Boiling point (ºC)	32.1	37	42.3	48	31.9
Flash point (ºC)	-32	-20	-17	-12	None
Explosion limit (vol% in air)	5.0~23.0	11.7~23.5	1.8~8.4	6.7-18.0	5.6~17.7
ODP (CFC11=1)	0	0	0	0	0.11
GWP (CO_2=1)	Negligile	<25	<25	Negligile	725
λ[mW/(m•K)]	10.7 (25°C)	12.2	15.9 (20°C)	Not available	9.7 (25ºC)

*: Data from UNEP-FTOC Report 2010

Analysis of Current Final Solutions

Substance	Hydrocarbons	Water/CO_2
Flammability	Flammable & Explosive	None
Applications (Safety concern)	**All applications ex. "Spray"**	All applications
K-factor	Good	Bad
Applications (Insulation concern)	All applications	**Only few application with low insulation requirement, such as pipe, etc.**
Safety requirements	Very high	Low
Alteration and investment	Difficult and high	Easy and low
Cost and availability (Blowing agent only)	Low and easy to get	Very low and easy to get

Conclusion

1. Current 2 final solutions can not fulfill all applications;
2. Spray applications can not use flammable and explosive hydrocarbons, small foam makers of other applications are also not suitable to use normal hydrocarbons technology due to high investment cost;
3. Hope new substances from 4th generation blowing agents can be one choice of final solutions.

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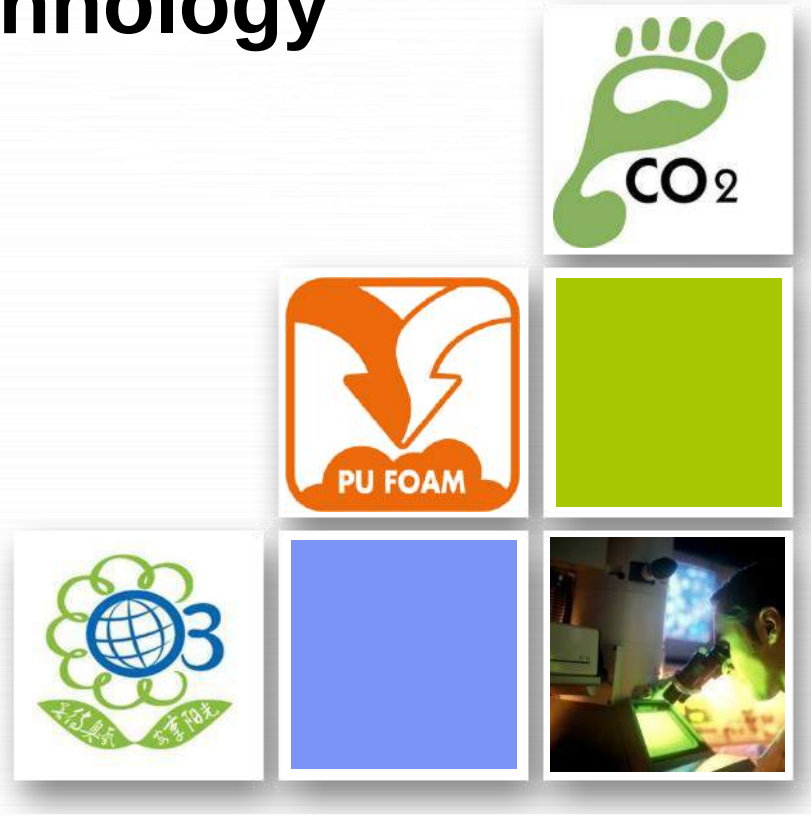
Hydrocarbons Technology



Hydrocarbons Analysis

- VOCs
- Flammable and explosive, low flash point
- High risk in transportation, storage and usage

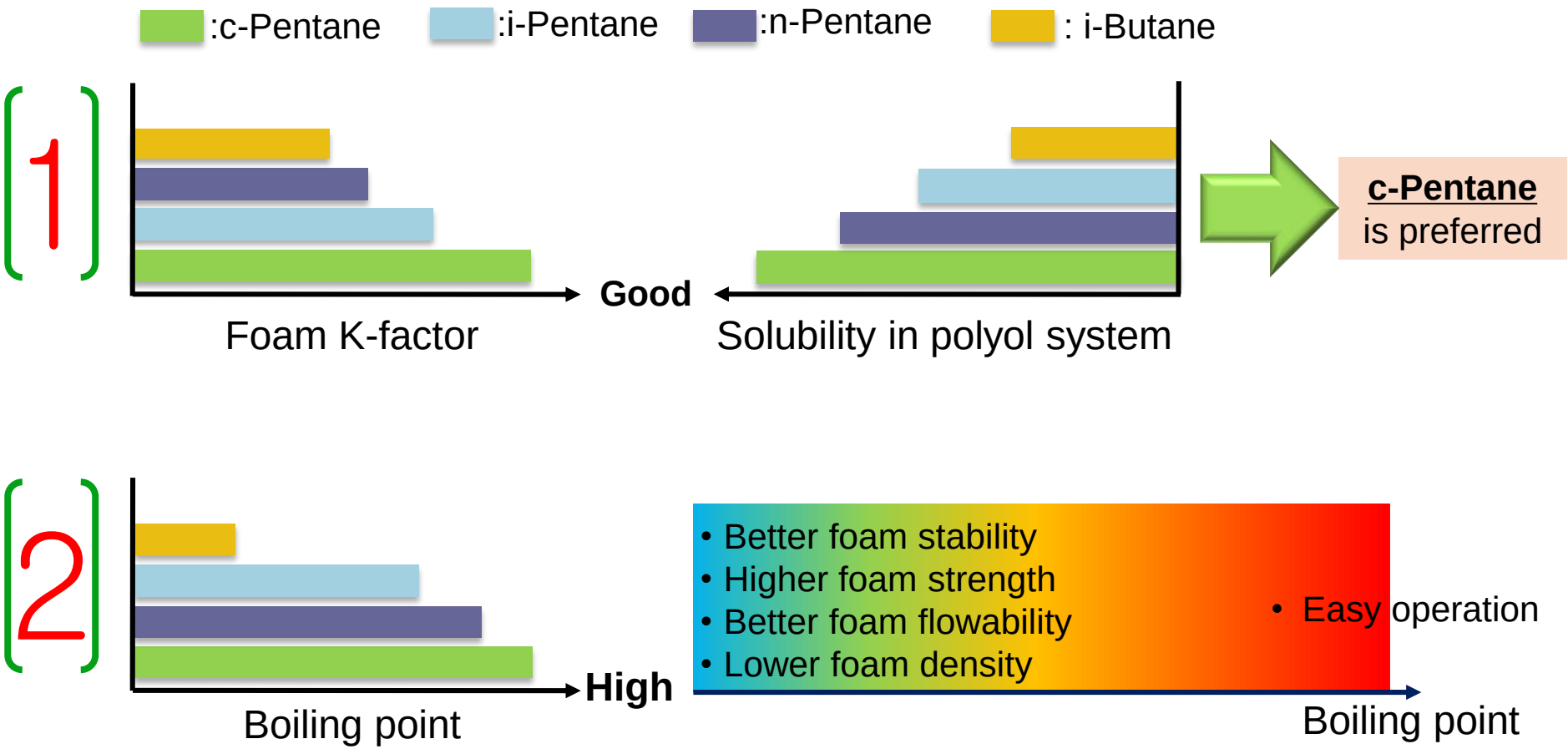
- Low cost, easy to get
- Low long-term running cost
- High investment for safety measures

- Poor solubility in normal poyols
- Bubbles, voids during foaming
- Normal K-factor, need balance foam stability

- Green product
- Final solutions

c-Pentane
n-Pentane
i-Pentane
i-Butane

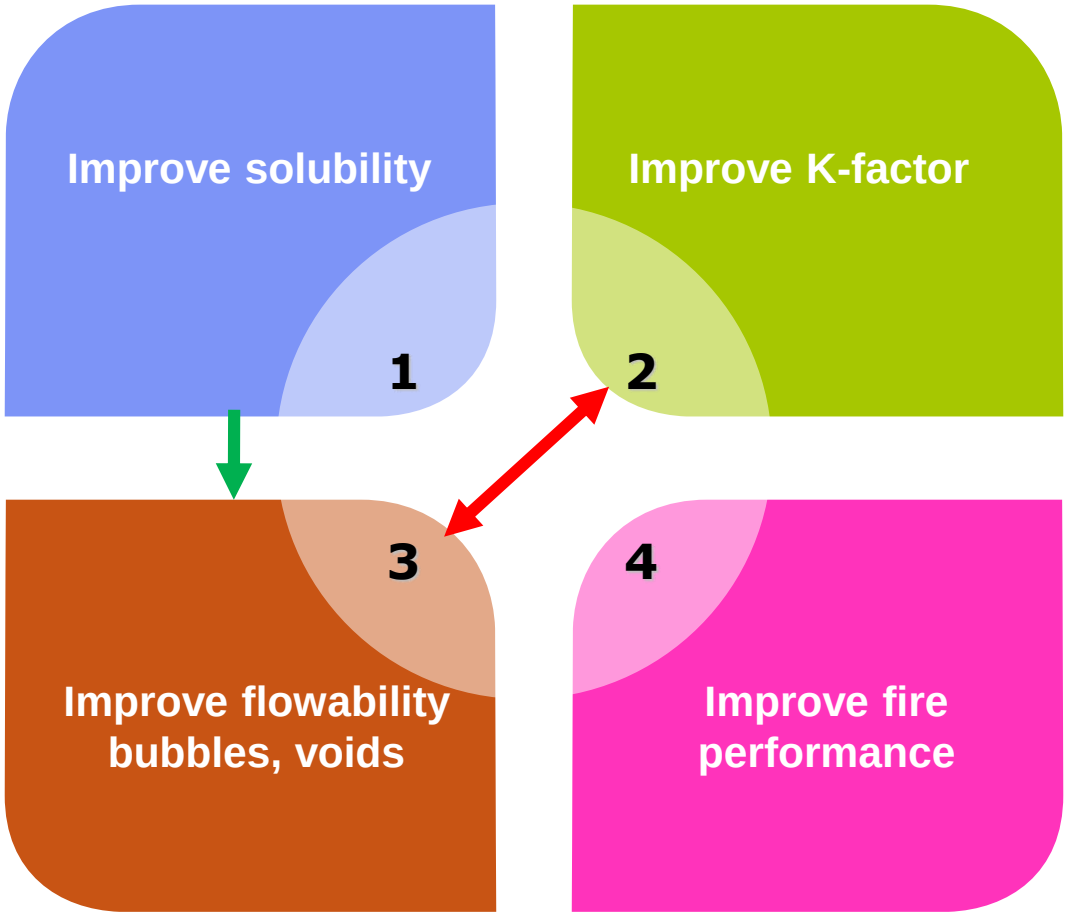
Hydrocarbons Analysis



1. n-Pentane is widely used in continuous PU panel/board industry
2. c-/i-Pentane=70/30(65/35) is used in appliance, c-Pentane/i-Butane=85/15~81/19

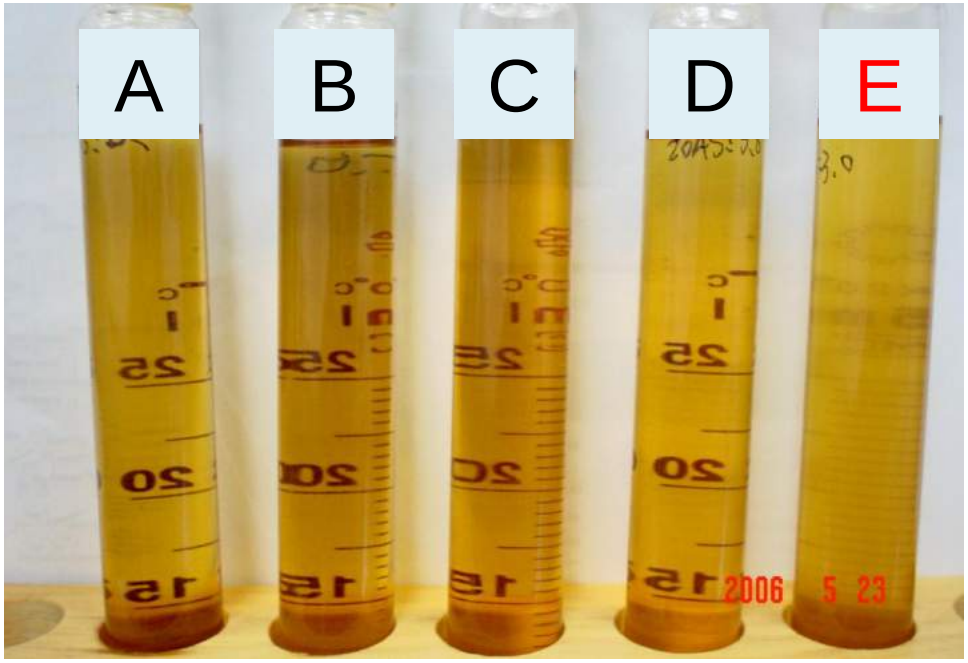
Hydrocarbons Analysis

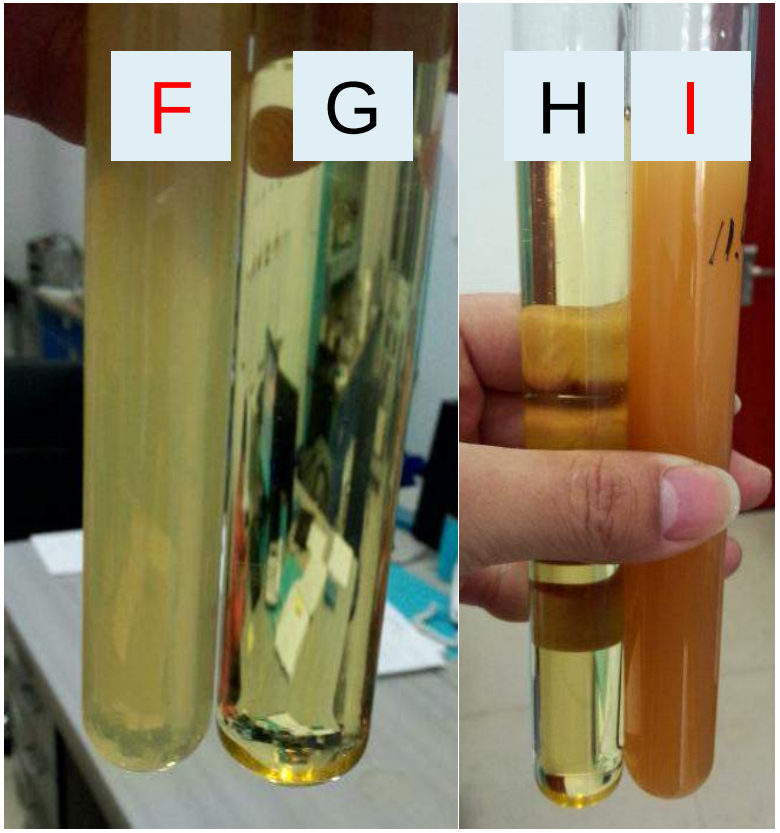
Formulation Development



1. Suitable polyols: Improve solubility, K-factor and balance the flowability.
2. Suitable surfactants, additives: Balance the flowability and reduce the bubbles and voids.

C5 Solubility





C5: Hydrophobic
Polyols/water/amine catalysts: Hydrophilic

E,F&I

Bad

- ◆May have phase separation especially in low temperature.
- ◆Leads to voids on the foam surface.
- ◆Affect foam flowability.

C5 Uselevel in Polyol Blends

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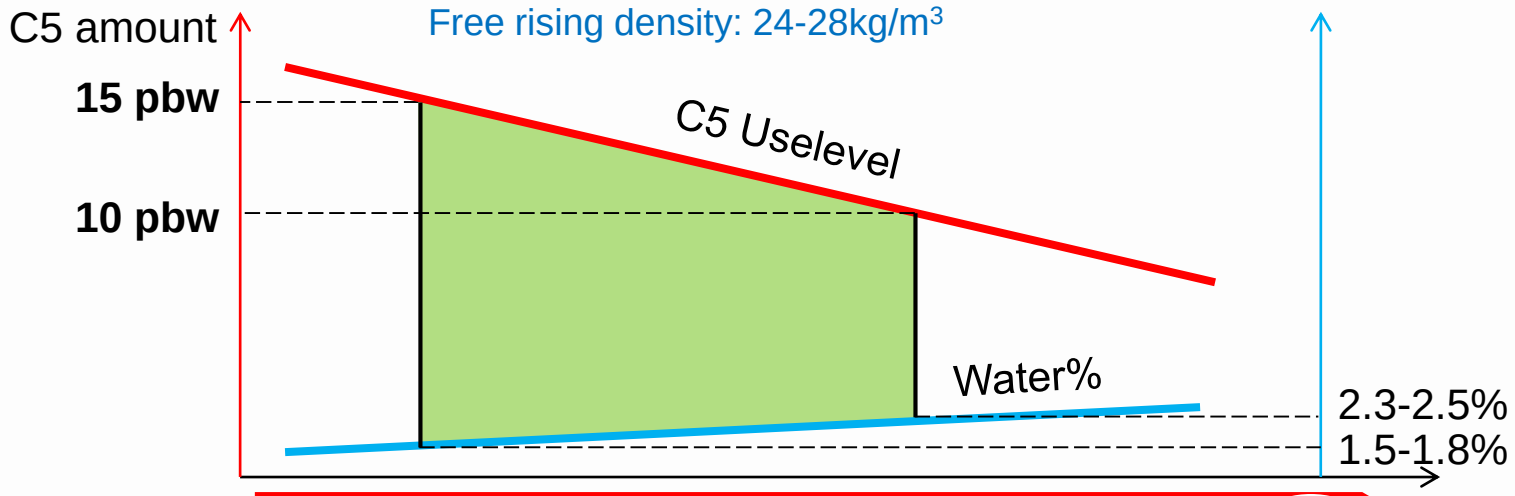
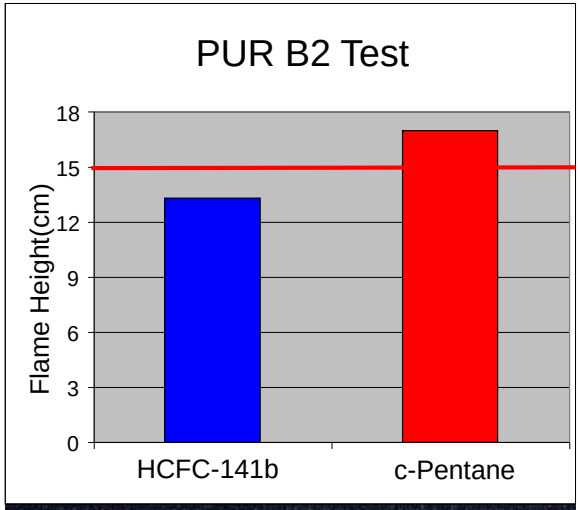
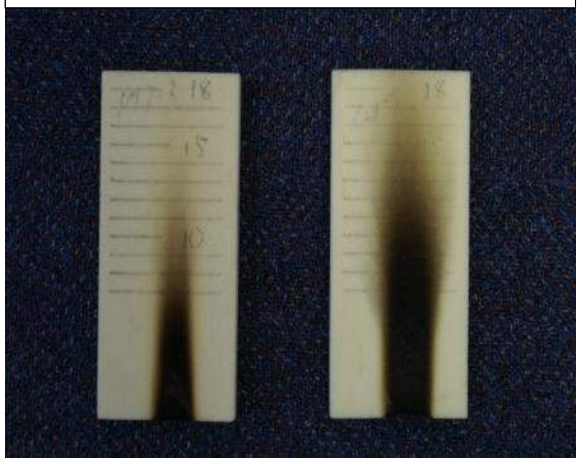
C5/Water Uselevel Correlation

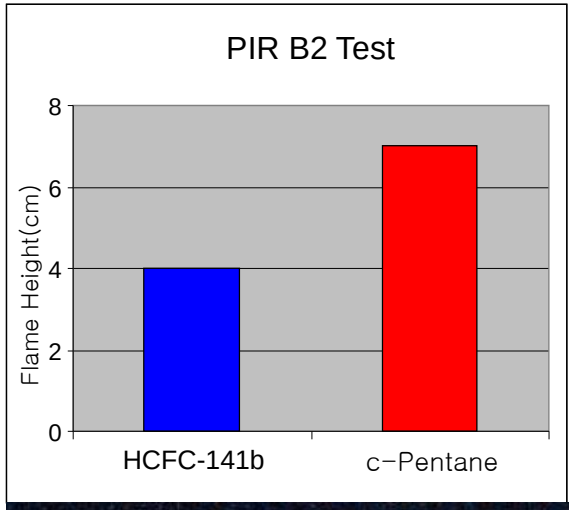


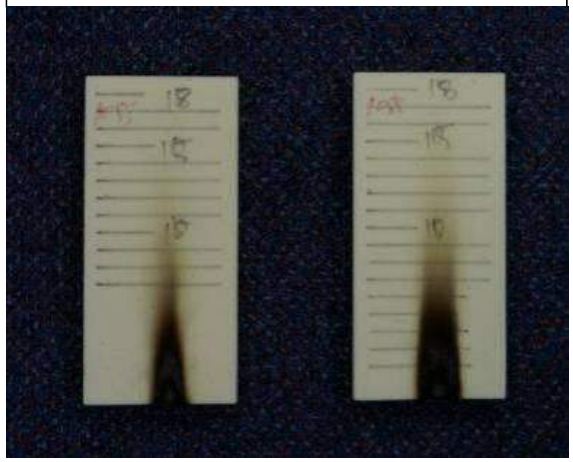
K-factor(insulation)	Bad
Foam flowability	Good
Voids	Good
Adhesion	Bad
Viscosity of system	Bad

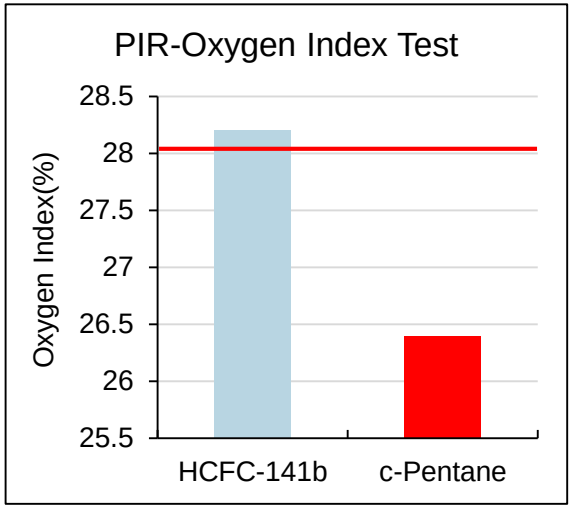
Flame Retardance with Hydrocarbons











Foam with oxygen Index>28%
may pass B1-class test

B2-class requirement: Flame Height<15cm

DIN4102-2 Standard

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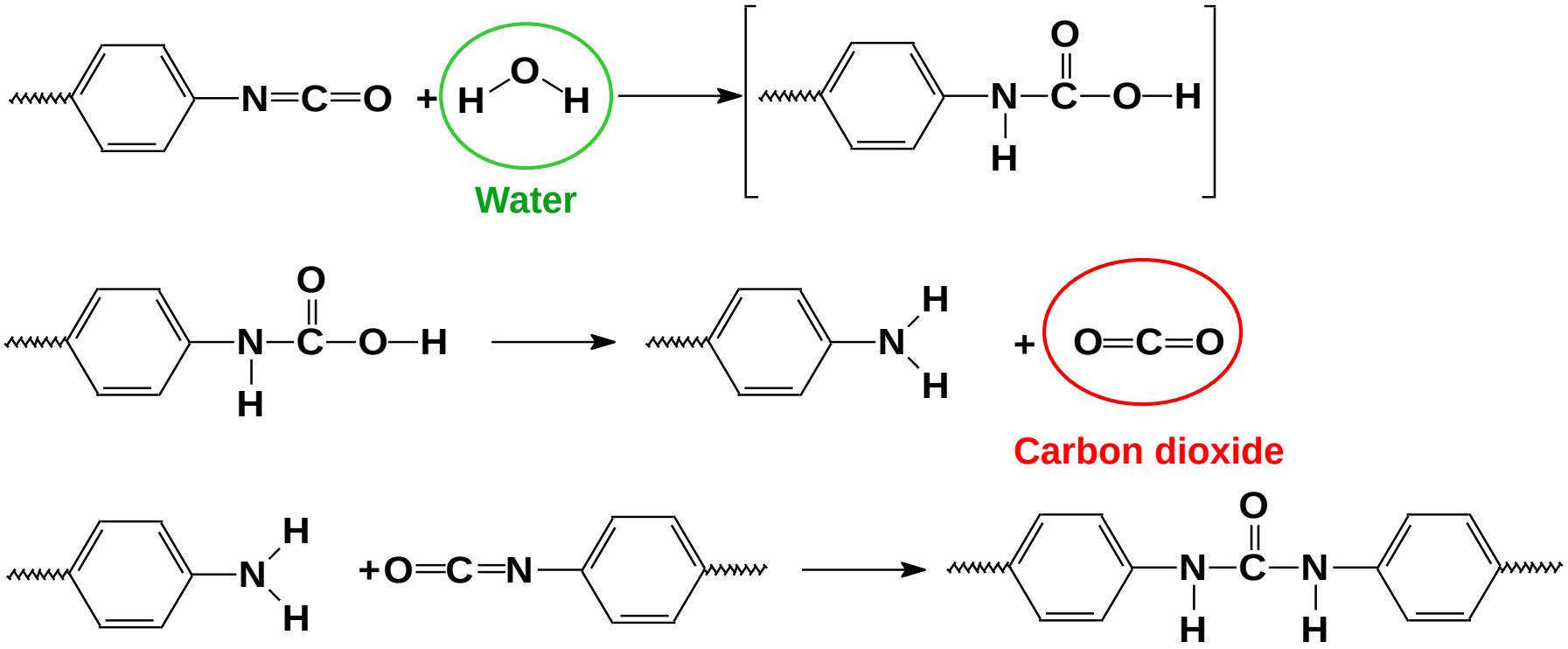
Water Blown Technology

“Water”as Blowing Agent



- “Water” is a chemical blowing agent, the real blowing agent is CO_2;
- “Water” is used as a co-blowing agent from CFC-11 generation.

Water Blown Analysis

- Worse foam K-factor
- High viscosity of polyol system
- Bad foam adhesion
- Bad foam stability

- Very low cost for blowing agent, but polyol system cost may be high.
- Worse insulation properties, may need increase insulation thickness.
- No need alteration on foaming machine, but may need investment on mold heating system
- Higher MDI/Polyol system ratio, may affect the foam cost

- Normally no safety issues
- Note: High heat release during foaming

All Water Blown

- Low GWP, green product
- Final solution;
- Worse K-factor, need consider energy consumption

Applications with “All Water” Technology

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HR foam:
-Car seat, Furniture, etc.

Semi-rigid foam/Automotive healiner

Integral skin foam:
-Steering wheel, etc.

Low density packaging foam,
high density imitation wood

Applications with “All Water” Technology

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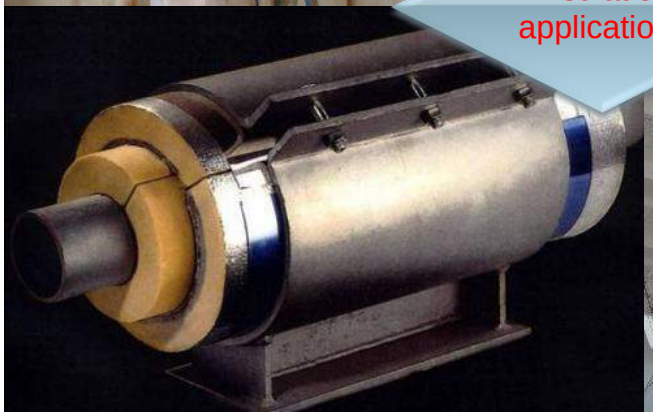
Spray foam: Japan & NA market

District heating and oil pipe

Insulation applications

High density pipe support



Air ducting, low density roof insulation panel

All Water Blown Analysis

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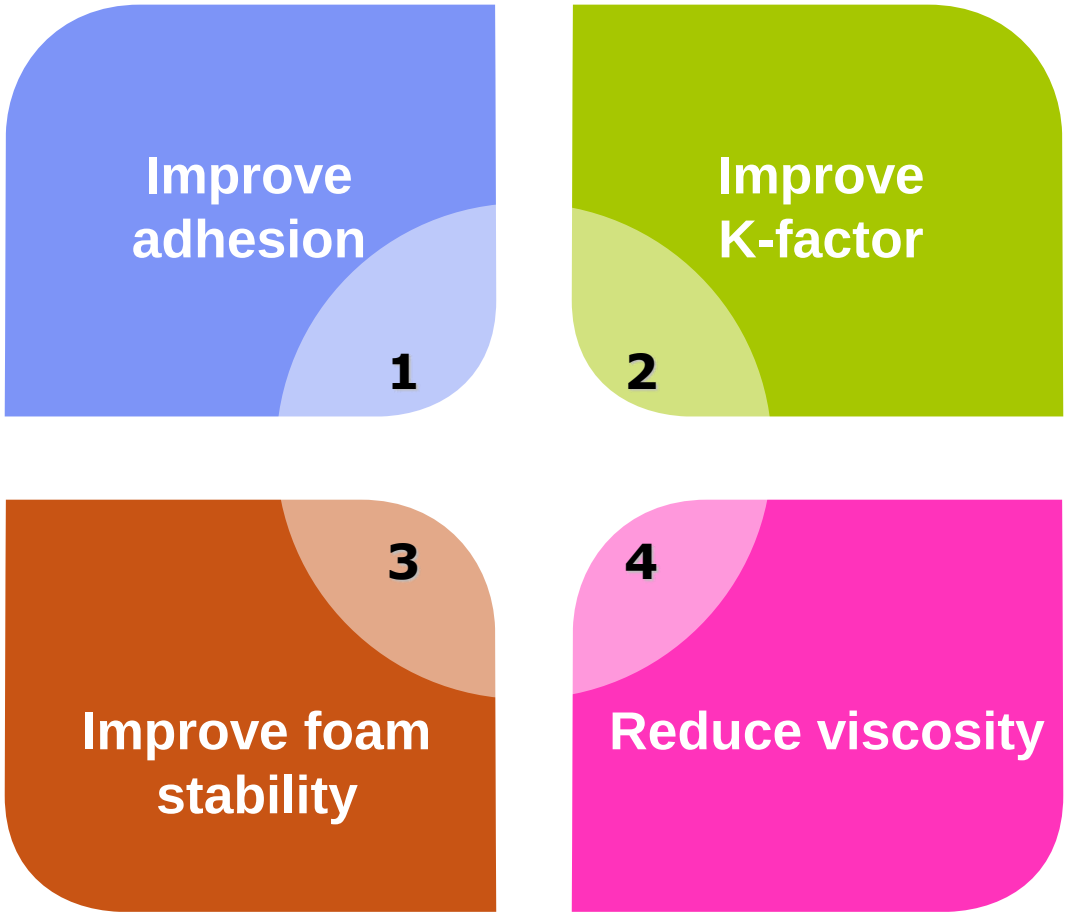
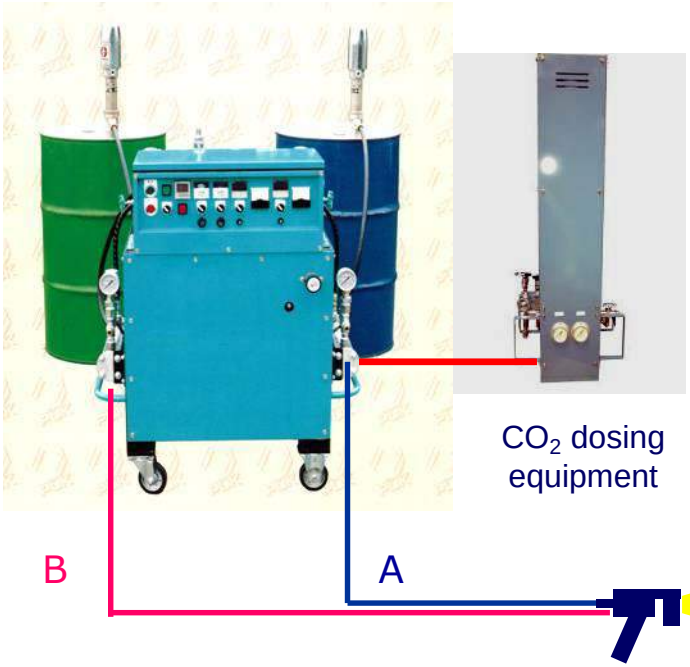
Formulation Development



1. Suitable polyols: improve K-factor, foam stability and reduce polyol system viscosity.
2. Suitable catalysts, additives: Improve adhesion, reduce polyol system viscosity.

All Water Blown with Liquid CO_2

- Used in spray foam, developed with all water technology.
- Introduce small amount liquid CO_2 as a 3rd stream into polyol system.
- Widely used in spray foam in Japan.
- Normally it is open cell foam.
- Super-critical liquid CO_2 is developed now.



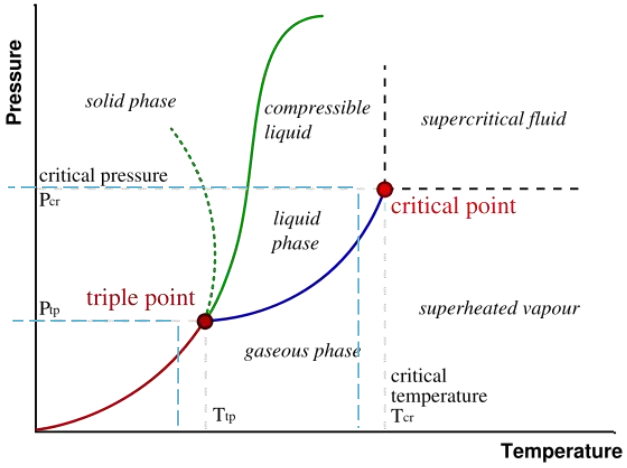
CO_2 dosing equipment

Advantage

- Fast cream time, can achieve fast spray
- Can reduce foam density
- Fast reaction at low temperature.
- better cell structure and K-factor.

Disadvantage

- Need additional equipment, less flexibility on-site.



4th Generation-H(C)FOs

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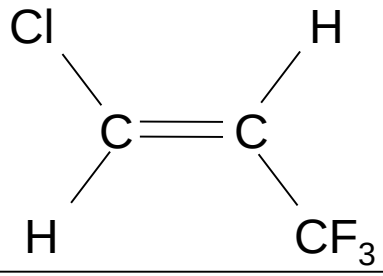
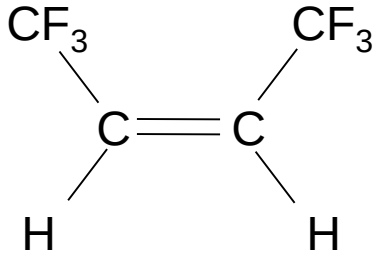
HCFO-1233zd(E)	HFO-1336mzz
 MW:130	 MW:164
■ Boiling point:19ºC → HFC245fa:15ºC	■ Boiling point:33ºC →HCFC141b:32ºC
■ Chlorine, double bond, bad stability	■ Double bond, no chlorine, good stability
■ MW:130 → HFC245fa:134	■ MW:164 >> HFC365mfc:148
■ Suppliers: US: Honeywell---Solstice LBA EU: Arkema---Forane 1233zd	■ Suppliers: US: Chemours---Opteon 1100

Price vs. Performance?

H(C)FOs Analysis

- Price is very high, limited suppliers;
- Long term operation cost is very high;
- No need investment for equipment;

- No safety issues.

- MW is high, uselevel is high;
- Boiling point of LBA is low and stability is not good;
- Solubility with polyol is good, K-factor is good.

- Low GWP, green product;

Solstice LBA
Opteon 1100

Methyl Formate

ecomate® BY FOAM SUPPLIES, INC.

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Disadvantage

- Methyl formate as a blowing agent in polyurethane industry is patented by Foam Supplies Inc. under the trademark of Ecomate®, patent no.: 6753357 (*: information from FTOC 2010 report);
- Strong plasticizer, bad foam stability and demolding properties;
- Bad stability in polyol blends due to hydrolysis of ester especially in alkali condition (polyol blends).

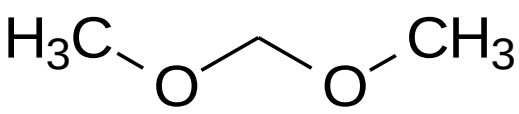
$$HCOOCH_3 + H_2O \rightleftharpoons HCOOH + CH_3OH$$

- Can find CO in foam cell, that prove hydrolysis of methyl formate.
- Not suitable as a sole blowing agent in normal rigid foam applications.
- Methyl formate is flammable liquid, flash point: -32ºC
- Smell and toxicity

Advantage

- Low MW(60), same as c-Pentane;
- Flash point of pre-blend system is relative high, better than c-Pentane;
- Can be used as co-blowing agent;

Methylal



Disadvantage

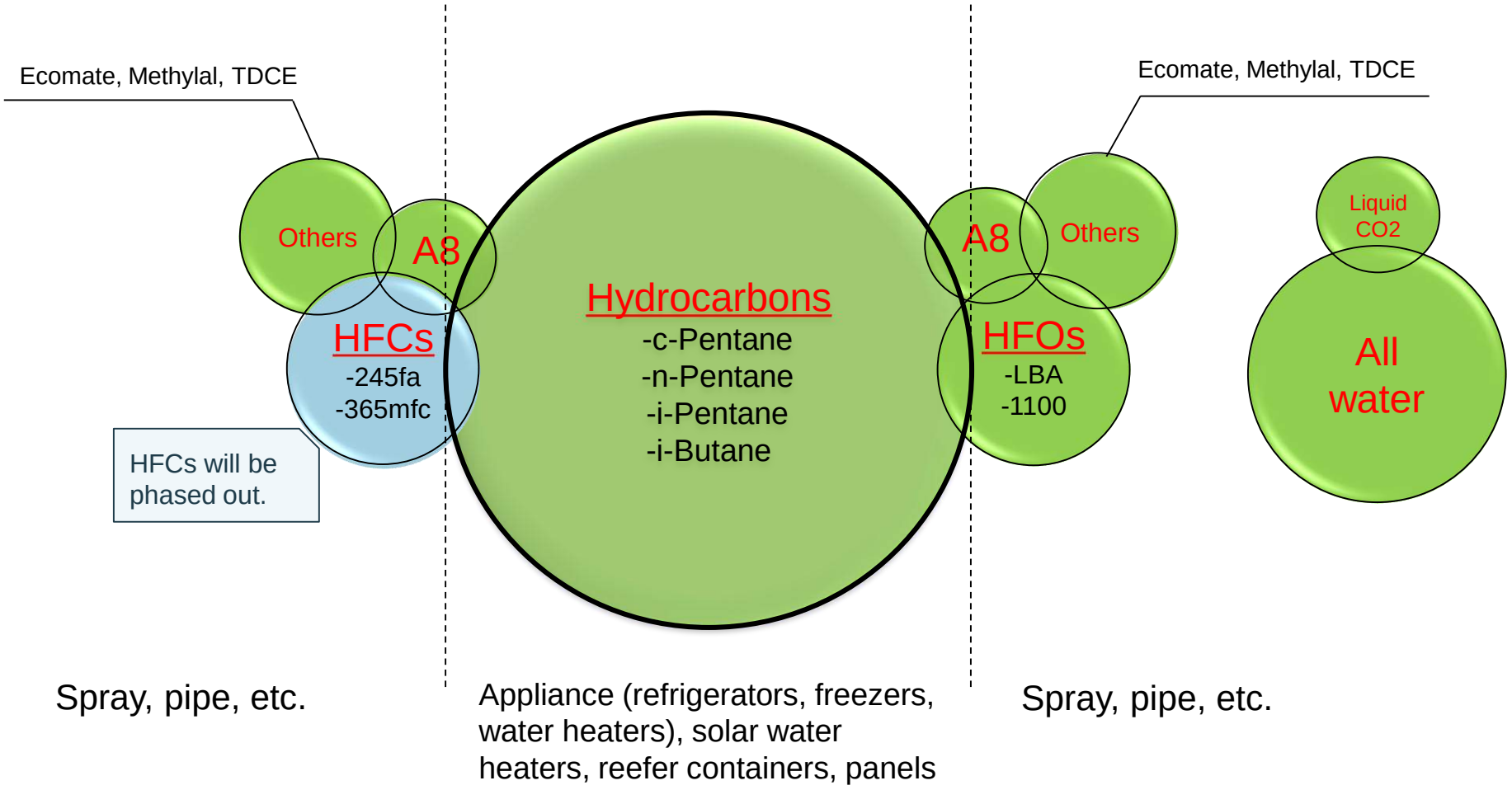
- It is a very strong solvent (stronger than acetone), very strong plasticizer, the foam stability is bad;
- Not suitable as sole blowing agent;
- Boiling point is high: 42.3ºC;
- Flammable liquid, flash point is -17.8ºC;
- Irritation and toxicity

Advantage

- Low GWP；
- Stable in polyol system;
- Low MW(76), uselvel is similar to c-Pentane;
- Flash point of pre-blended system is relative high, better than c-Pentane;
- Can be a co-blowing agent;

Alternatives

HCFC-141b Substitution Trend



PIR Conti-Panel Study-1

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Compare the uselevel & reactivity with same polyol blends and similar FRD.

Formulation	141b	n-Pentane	i-Pentane	c-Pentane	Water	LBA	1100
Polyol blends (1.1% water) (pbw)	100	100	100	100	100	100	100
Blowing agent (pbw)	26	14.5	14.5	14.5	2.80	28	39
MDI (pbw)	230	230	230	230	230	230	230
INDEX	480	480	480	480	250	480	480
Ratio (MDI/Polyol)	170/100	188/100	188/100	188/100	208/100	170/100	160/100
CT (s)	11	9	8	11	14	8	9
GT(s)	86	103	107	88	90	92	100
FRD(kg/m^3)	36.2	36.1	36.1	36.3	36.4	35.8	35.8

PIR Conti-Panel Study-2

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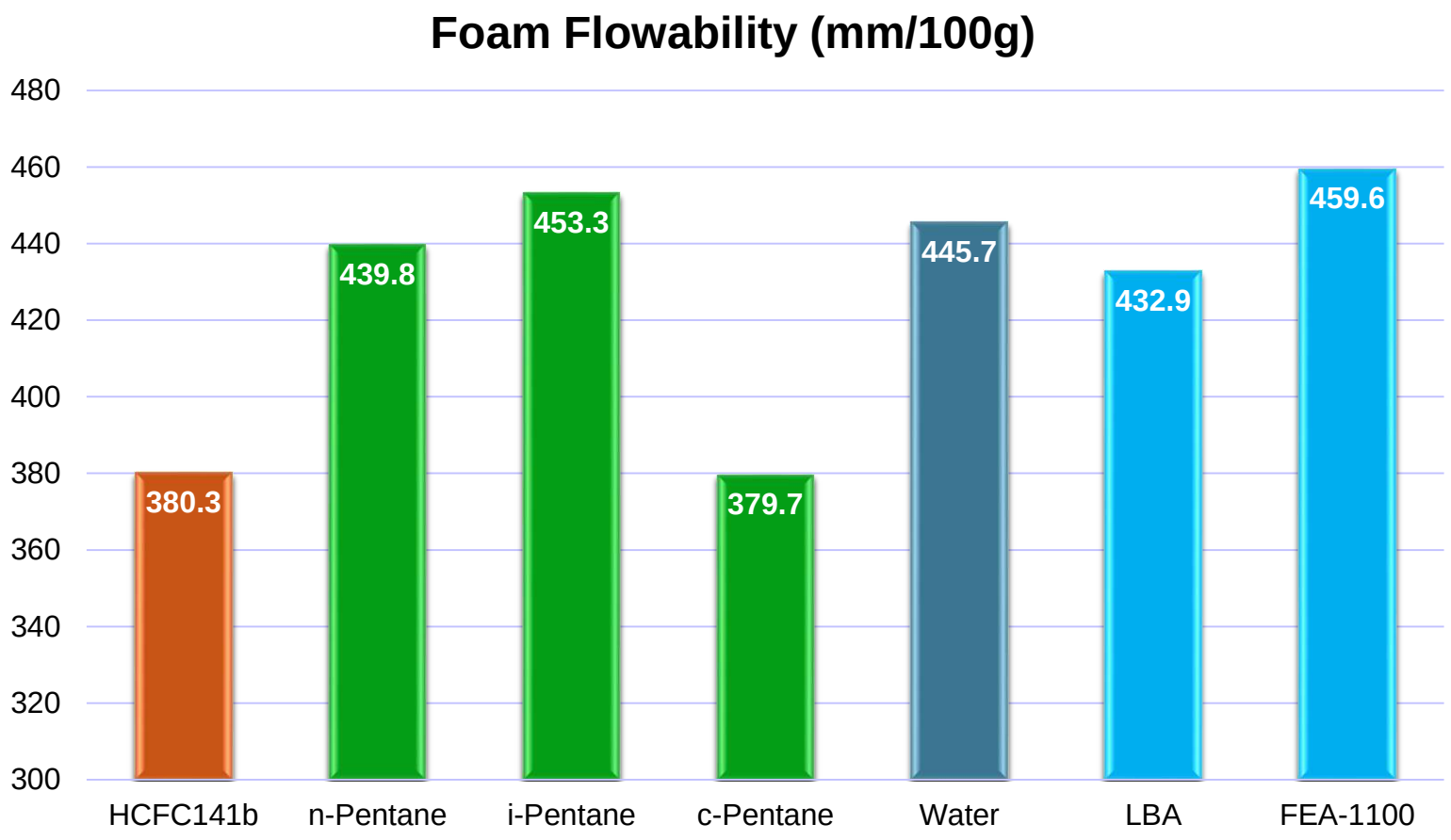
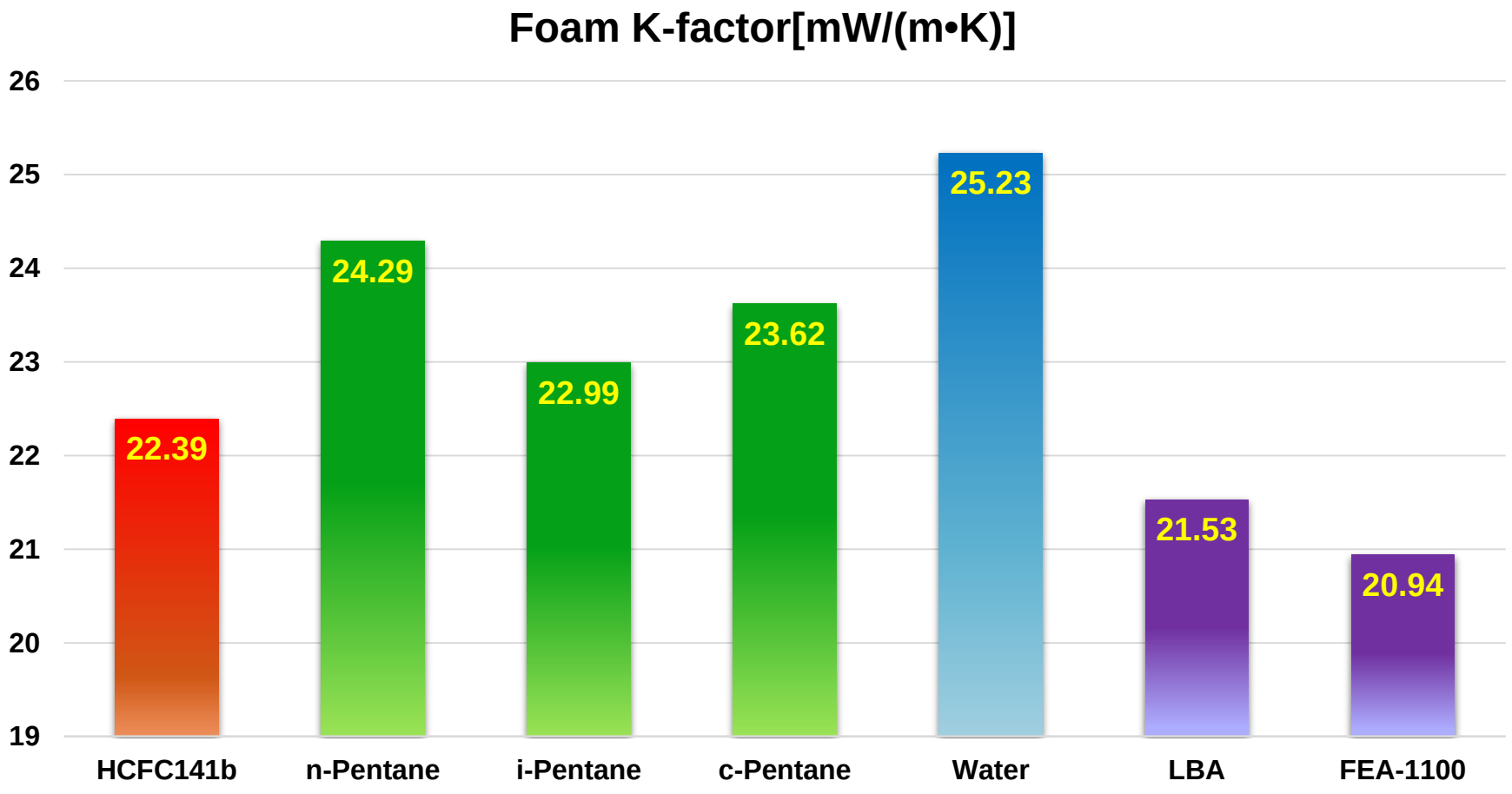
Compare the uselevel with same polyol blends and similar reactivity, FRD.

Formulation	141b	n-Pentane	i-Pentane	c-Pentane	Water	LBA	1100
Polyol blends (1.1% water) (pbw)	100	100	100	100	100	100	100
Blowing agent (pbw)	26	14	14	14.5	2.80	27	36
MDI (pbw)	230	230	230	230	230	230	230
INDEX	480	480	480	480	250	480	480
Ratio (MDI/Polyol)	170/100	188/100	188/100	188/100	208/100	170/100	160/100
CT (s)	11	9	9	11	10	10	10
GT(s)	86	87	87	88	87	91	92
FRD(kg/m^3)	35.5	36.3	36.3	36.1	36.1	35.9	35.8

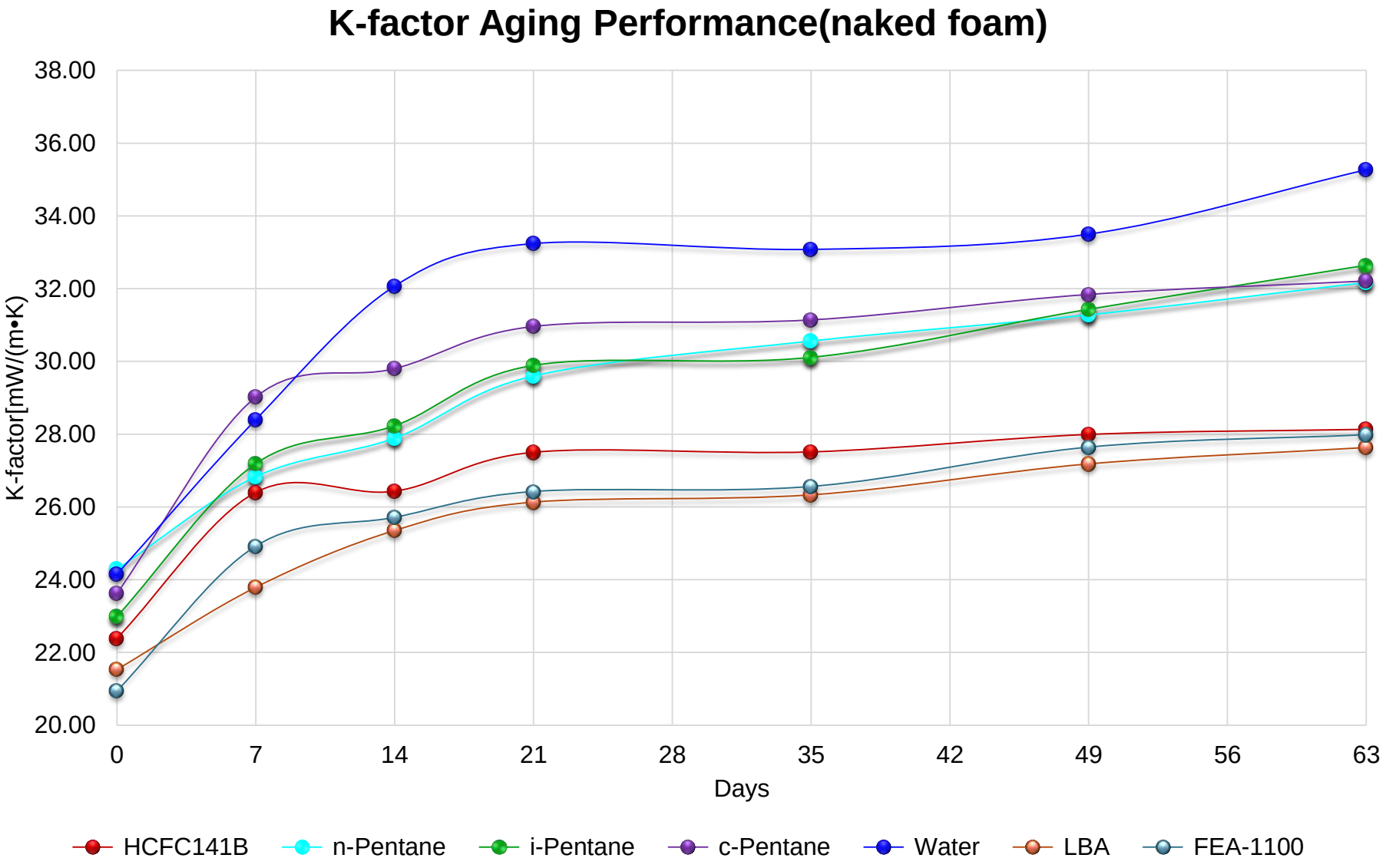
PIR Conti-Panel Study-2



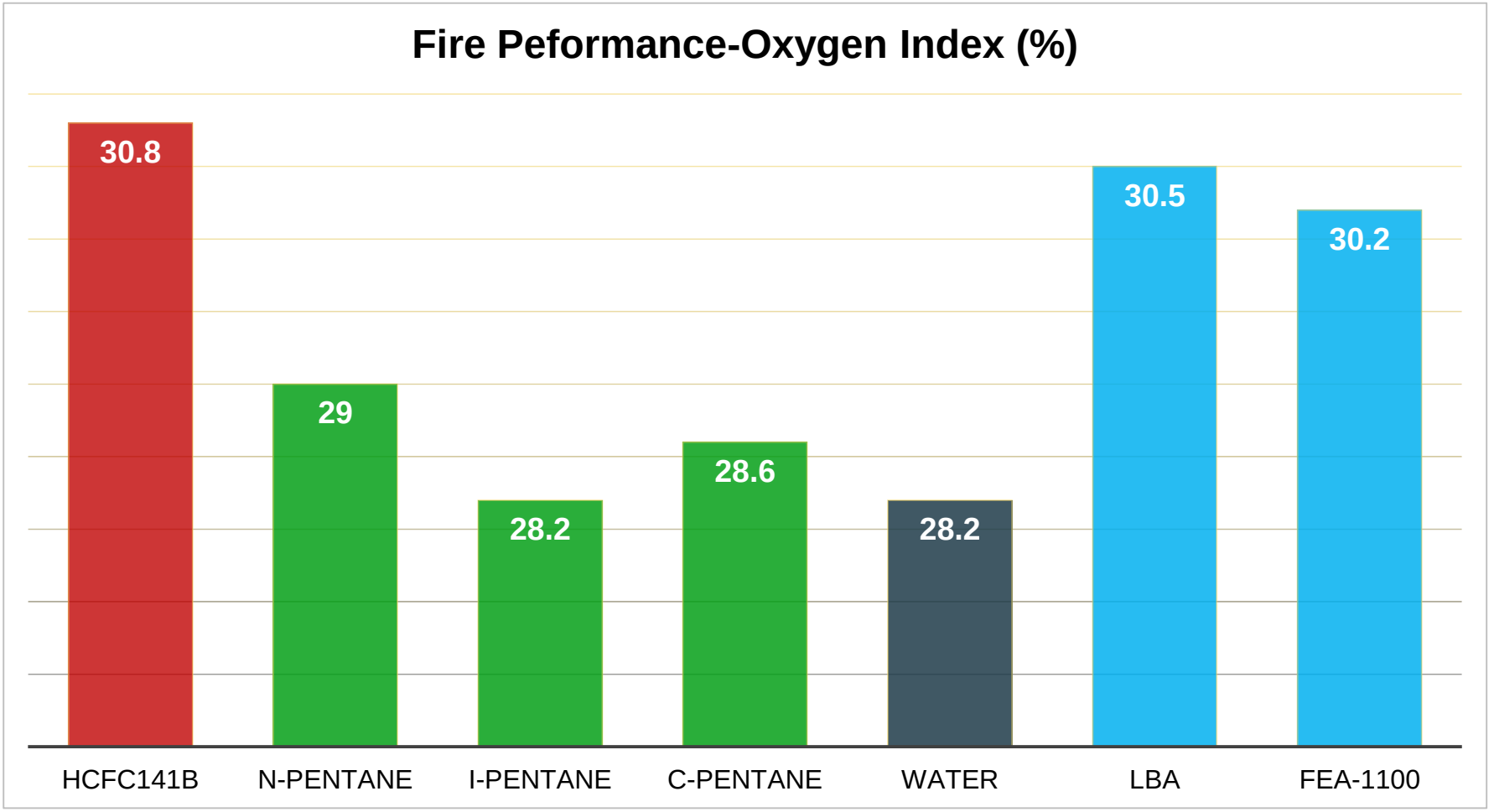
PIR Conti-Panel Study-2



PIR Conti-Panel Study-2



PIR Conti-Panel Study-2



Thanks for your attention

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Safety Training for C5 Technology

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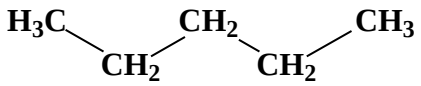
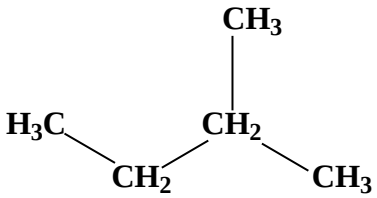
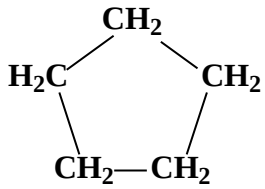
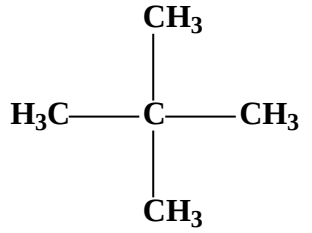
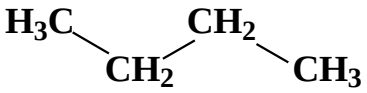
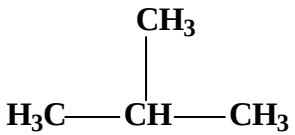
C5 Introduction

C5: Hydrocarbons with 5 carbon atoms

Chemical Name	n-Pentane	Iso-Pentane	Cyclo-Pentane	Neo-Pentane
Structure				
Boiling Point (ºC)	36.1	28	49	9.5
Flash Point (ºC)	-49	-57	-42	<-7
Explosion limit in air (%)	1.4-8.0	1.4-8.3	1.5-8.7	1.4-7.5
Gas λ[mW/(m•K)]	14.0(10ºC)	13.0(10ºC)	11.0(10ºC)	14.9 (25ºC)

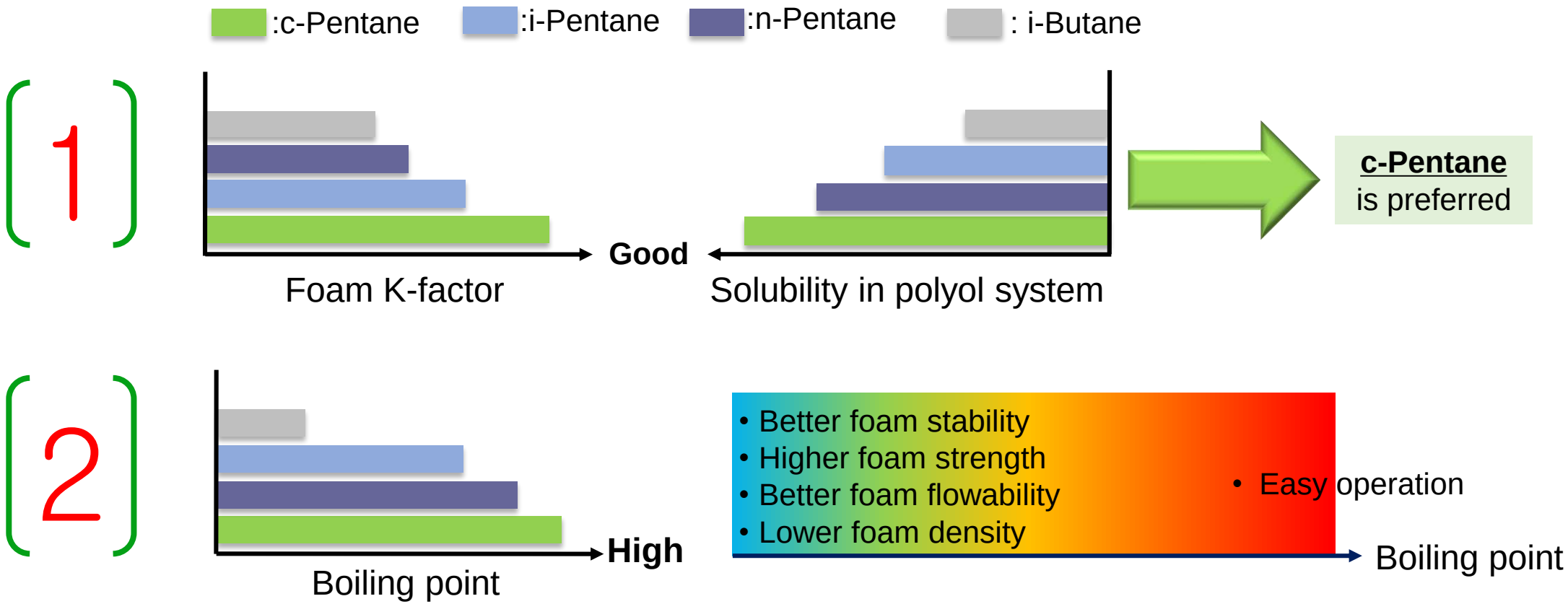
2 types of C4

Other hydrocarbons: n-Butane and Iso-Butane can also be used as blowing agent in some applications.

Chemical Name	Structure	Boiling Point (ºC)	Flash Point (ºC)	Explosion limit in air (%)	Gas λ [mW/(m•K)]
n-Butane		-0.45	-60	1.8-8.5	13.6(0ºC)
Iso-Butane		-11.7	-107	1.8-8.4	15.9(20ºC)

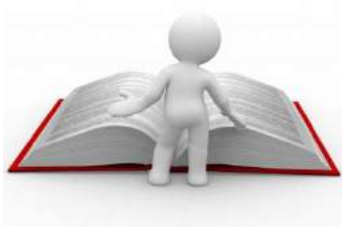
C4: Iso-Butane is also used as blowing agent in some polyurethane applications

Selection of Hydrocarbons (C5 & C4)



- c-Pentane and n-Pentane can be used alone, c-Pentane for appliance, n-pentane for conti. Panel/board.
- i-Pentane & i-Butane are normally mixed with c-Pentane
- c-/i-Pentane=70/30(65/35), c-Pentane/i-Butane=85/15~81/19 is used in appliance industry

Safety Measures for C5 technology



Recognize Danger

+

Improve Safety Mindset

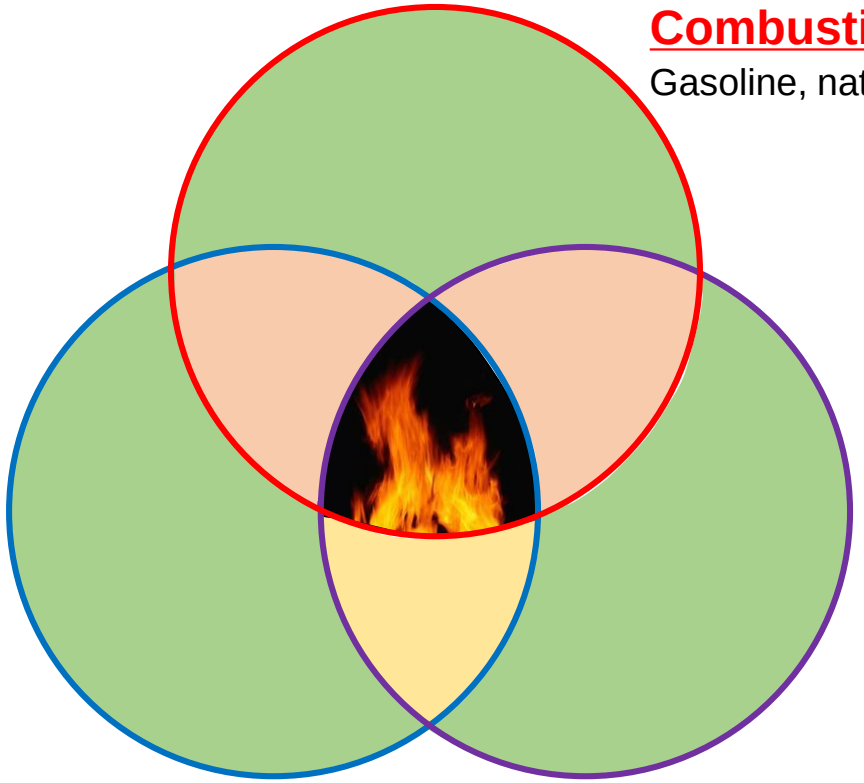
+

Right Risk Control

Safe Operation

Inflammation/Explosion

3 Element Factors for Inflammation：



Combustible
Gasoline, natural gas, etc.

Comburant
Air, O_2,
oxidants, etc.

Ignition Source
Fire, spark, heat,
static electricity, etc.

Additional factor for explosion

Combustible concentration

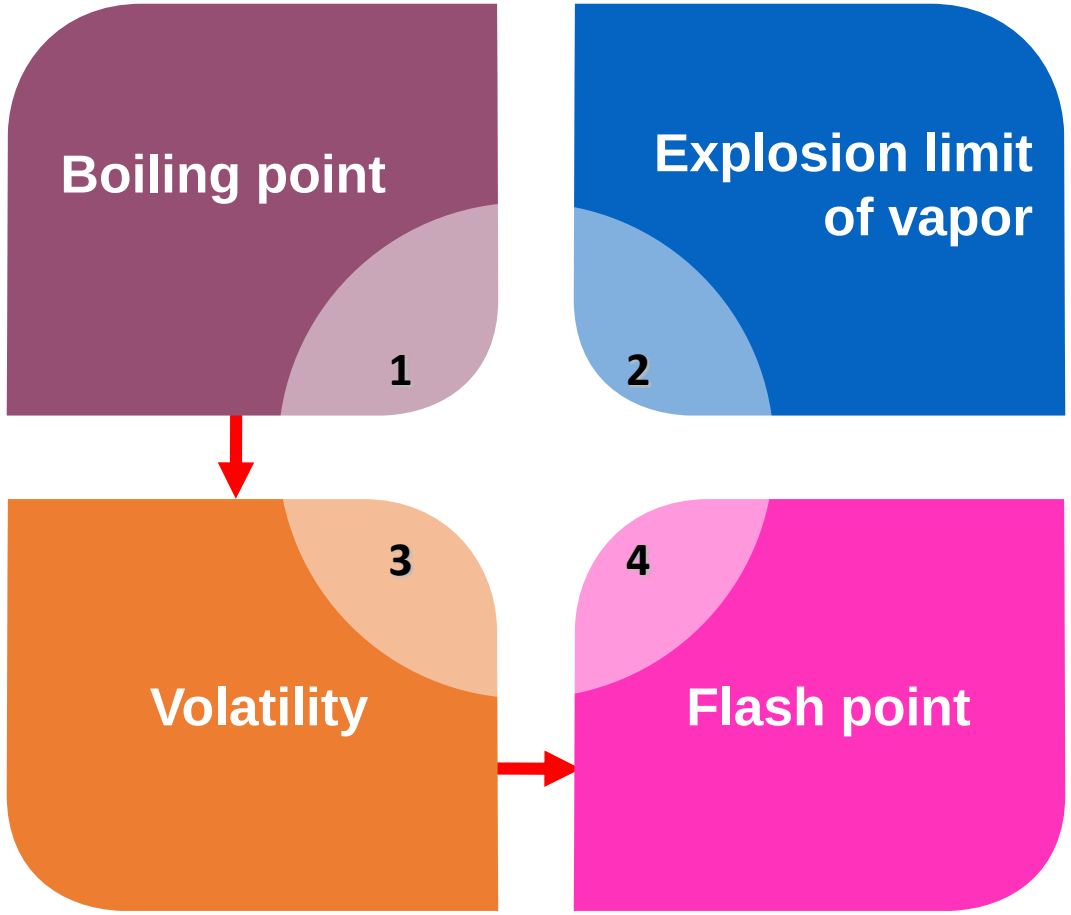
Explosion Limit

Concentration of Combustibles (gas, vapor or dust) in air (or oxygen) reach a certain range. It will cause explosion with ignition source.

Lower LEL and wider range means higher explosion risk.

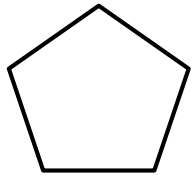
- H_2： Explosion limit (vol) in air: 4.0~75% **High Risk**
- CH_4： Explosion limit (vol) in air: 5.0~15.4%

Risk of Flammable Liquid



- The **flash point** of a volatile material is the lowest temperature at which vapors of the material will ignite, when given an ignition source.
- Flammable liquid with lower flash point has higher volatility and risk.

Recognize Danger of C5 (c-Pentane)

c-Pentane: C_5H_{10}  MW：70.1

Boiling point：49ºC
Flash point：-42ºC
Vapor pressure：318mmHg/20ºC
Explosion limit：1.5-8.7%
Vapor density：2.42/20ºC (air=1）
Liquid density：0.746g/cm^3 (20ºC)

- Flash point / Vapor pressure → VOC-High volatility
- Explosion limit → High explosion risk
- Vapor density → Easier concentration
- Liquid density → On top of polyol when separation

- In a 20m^2 room(height=5m), if c-Pentane vapor is distribute evenly, around 4kg c-Pentane could achieve the explosion LEL. Actually the amount to get explosion is much lower than 4.0kg as c-Pentane will concentrate on the ground.
- **200L steel drum with c-Pentane pre-blended polyol: If used half material, on the top of 100L space, only 5g c-Pentane vapor will get explosion LEL (about 10kg c-Pentane in the remaining half material).---High risk!!!**

Recognize Danger of c-Pentane

- Simulation of c-Pentane explosion

Min. energy to get explosion: 0.28mJ

Static, spark, mechanical impact, lightning

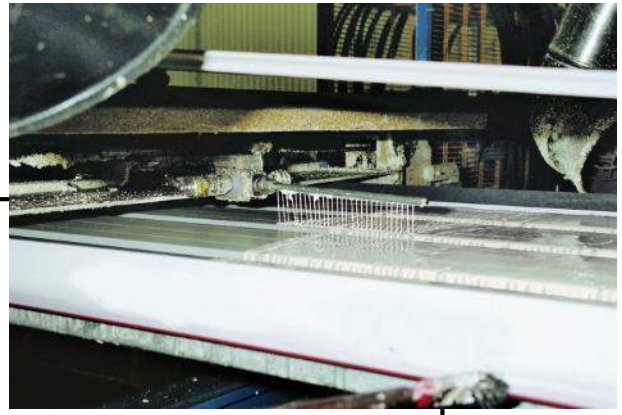
Explosion energy:
11 times of TNT.

Mold was broken and spar parts flied out.

Risks with Hydrocarbons

C5 storage tank

Foaming area

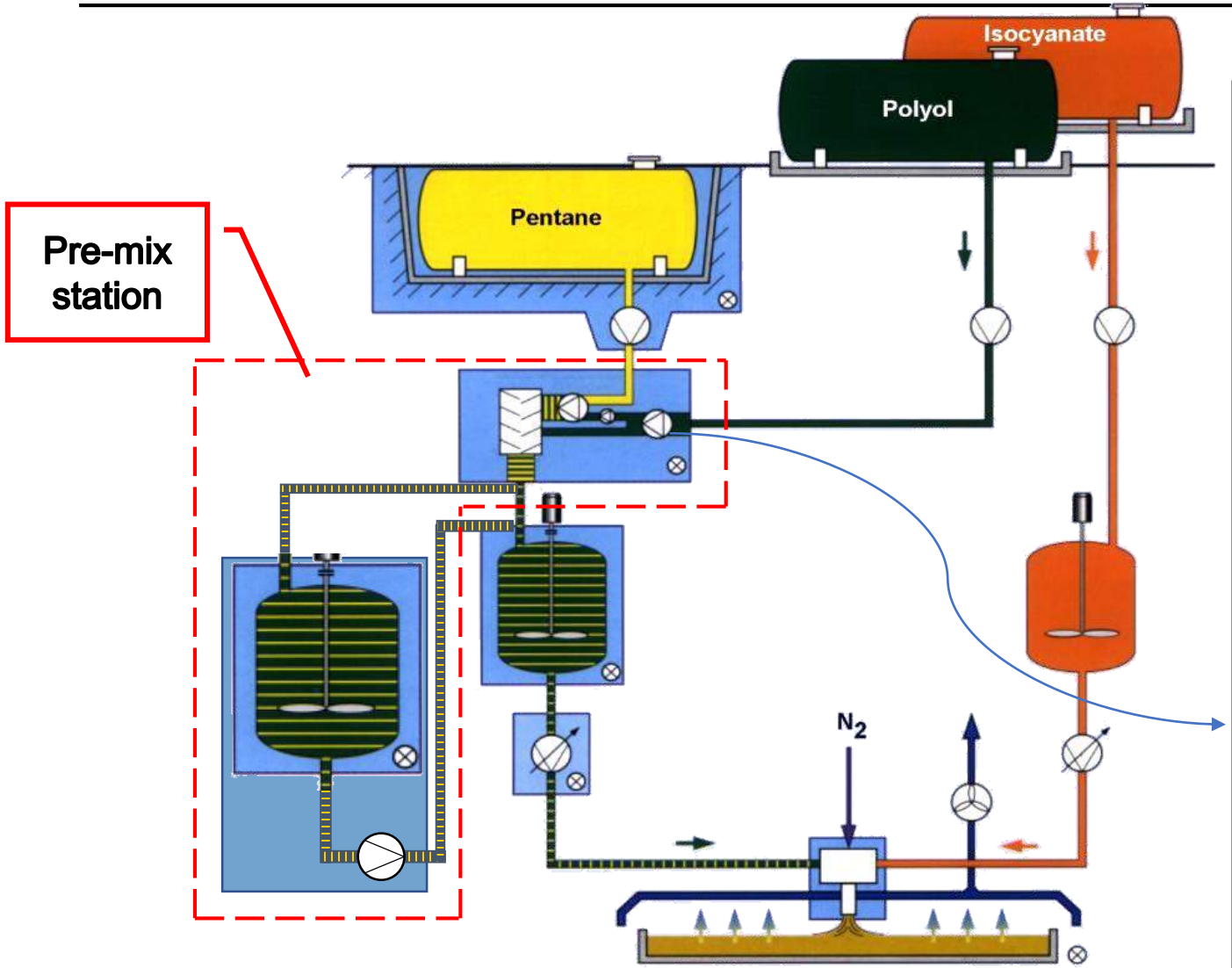


4 Dangerous Area

Pre-mixing station

Foaming machine

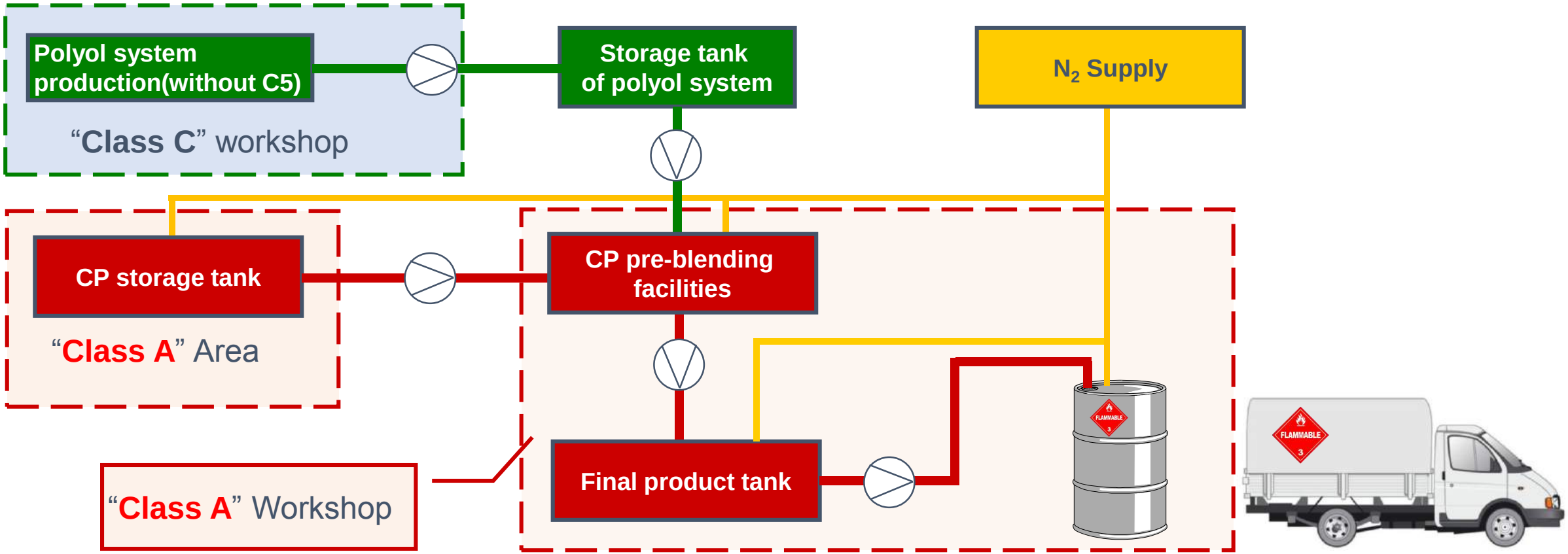
Normal Process for C5 Adoption



: Dangerous zone ⊗ : HC detector

C5 Pre-blended System

System house sets up c-Pentane pre-blending capacity



- The flash point of c-Pentane pre-blended system is around 0ºC, it is still flammable liquid.
- Transportation, processing and safety measures are important.

Customers with C5 Pre-blended System

Why customers need c-Pentane pre-blended system?

- C5 technology is preferred due to **low running cost**
- PU consumption is **relative low**;
- Plant **location limitation** (not allowed to install C5 storage tank, etc.)
- **Safety concerns**

Benefits for the customers

- Less investment, no **C5 storage tank**, **pre-mixing station** and related safety measures.
- Possibility to adopt low running cost **C5 technology**.
- May not need to change the **fire protection class** of the workshop.

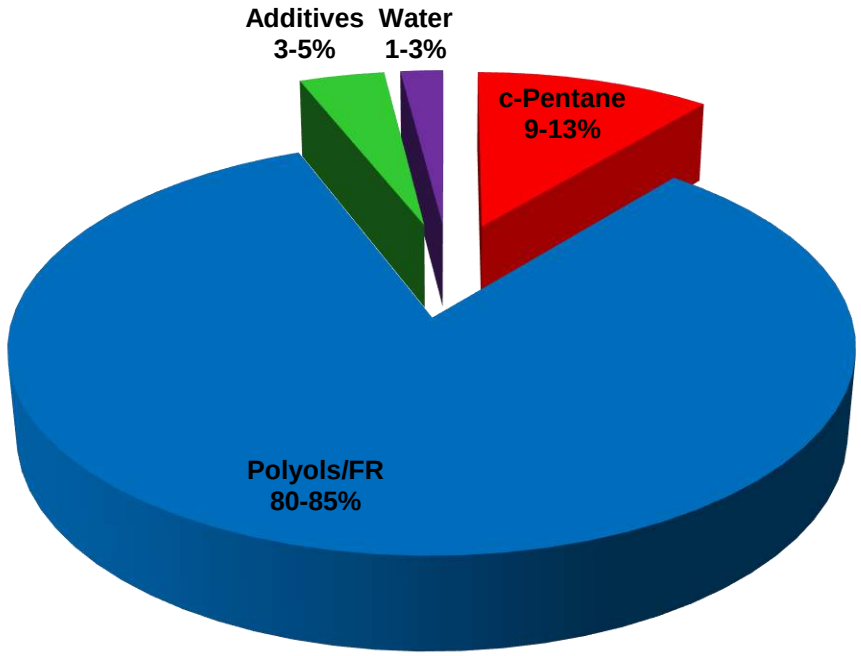
Safety measures needed for the customers

- **Foaming machine** change or alteration;
- Safety measures in **foaming area**(ventilation, monitoring and alarm system, etc.)
- Safety measures in **storage area** for pre-blended systems.

Danger of C5 Pre-blended System

Composition of c-P pre-blended system：

■Flash point of c-Pentane：**-42ºC**
■Flash point of other components：**>100ºC**



Flash Point
~0ºC

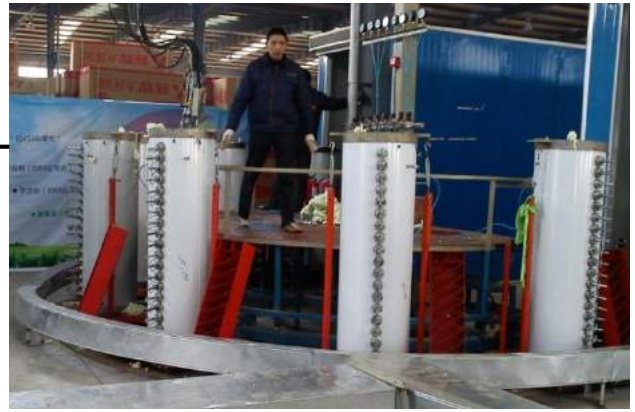
- VOC of C5
- Poor solubility of C5 in polyol

The vapor on top of C5 pre-blended system in normal condition (20-25ºC) during operation and storage is able to get flashover if air is exist.

Danger of C5 pre-blended system

Warehouse and storage tanks

Injection/foaming area



3 Dangerous Zone

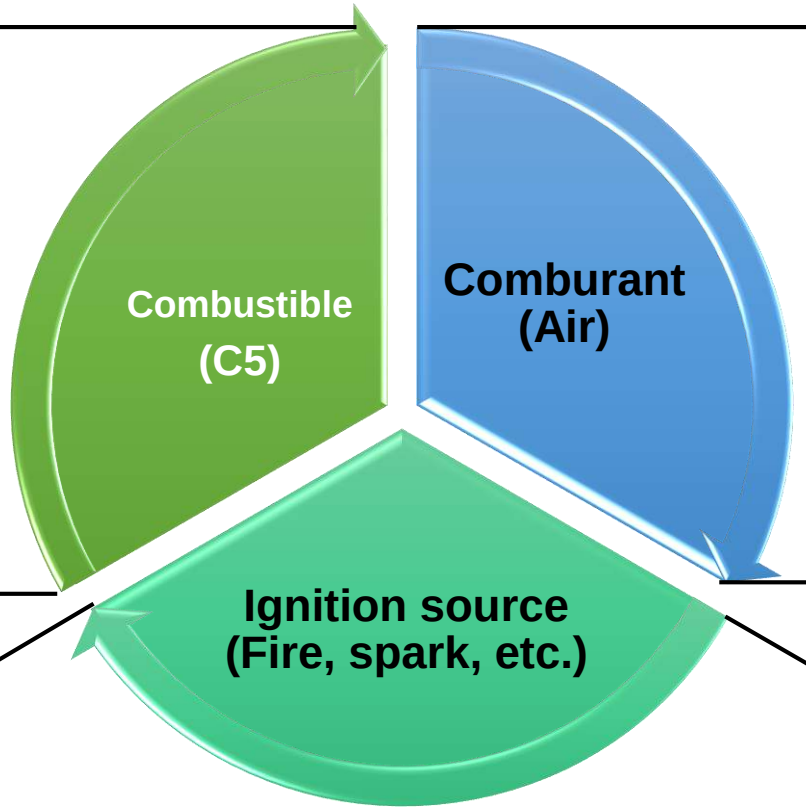
Foaming Machine

Risk Control Strategy

When combustible can not avoid, block the comburant:

- Drum or tank
- Foaming cavity

Method: N_2 replace air



When comburant can not avoid, control the combustible level

- Warehouse
- Foaming area

Method: Ventilation and detector

Block ignition source: It is an additional way to control risks。

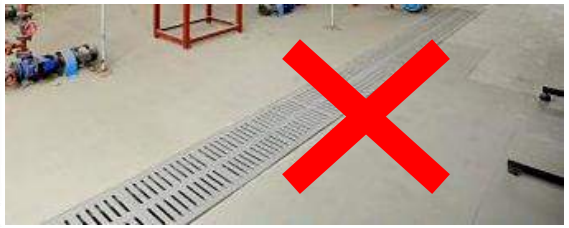
Method: Grounding, Ex-proof electrics, etc.

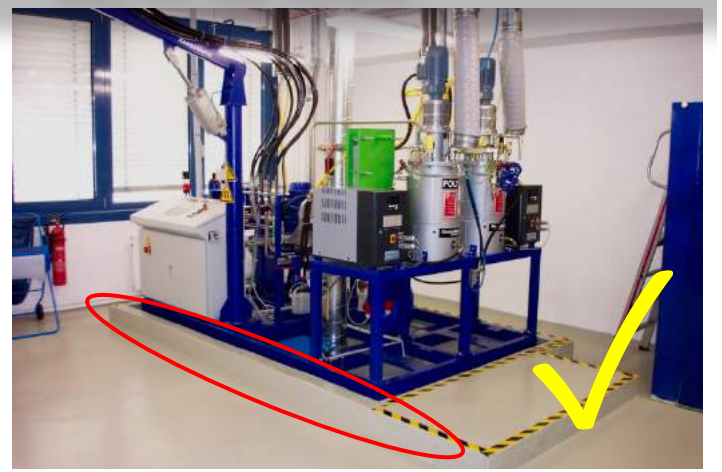
NEXT PAGE

Risk Control Strategy

No Fire | No Matches | No Chemical Fiber Clothes | No Spikes | No Mobile Phone | Grounding/ Earthing

- NO trenches in the dangerous zone (**Wire trenches**)
- Right installation of **Detectors and Ventilation Openings**: Close to the ground
- Set up barrier or isolate dangerous zone is good way for risk control.



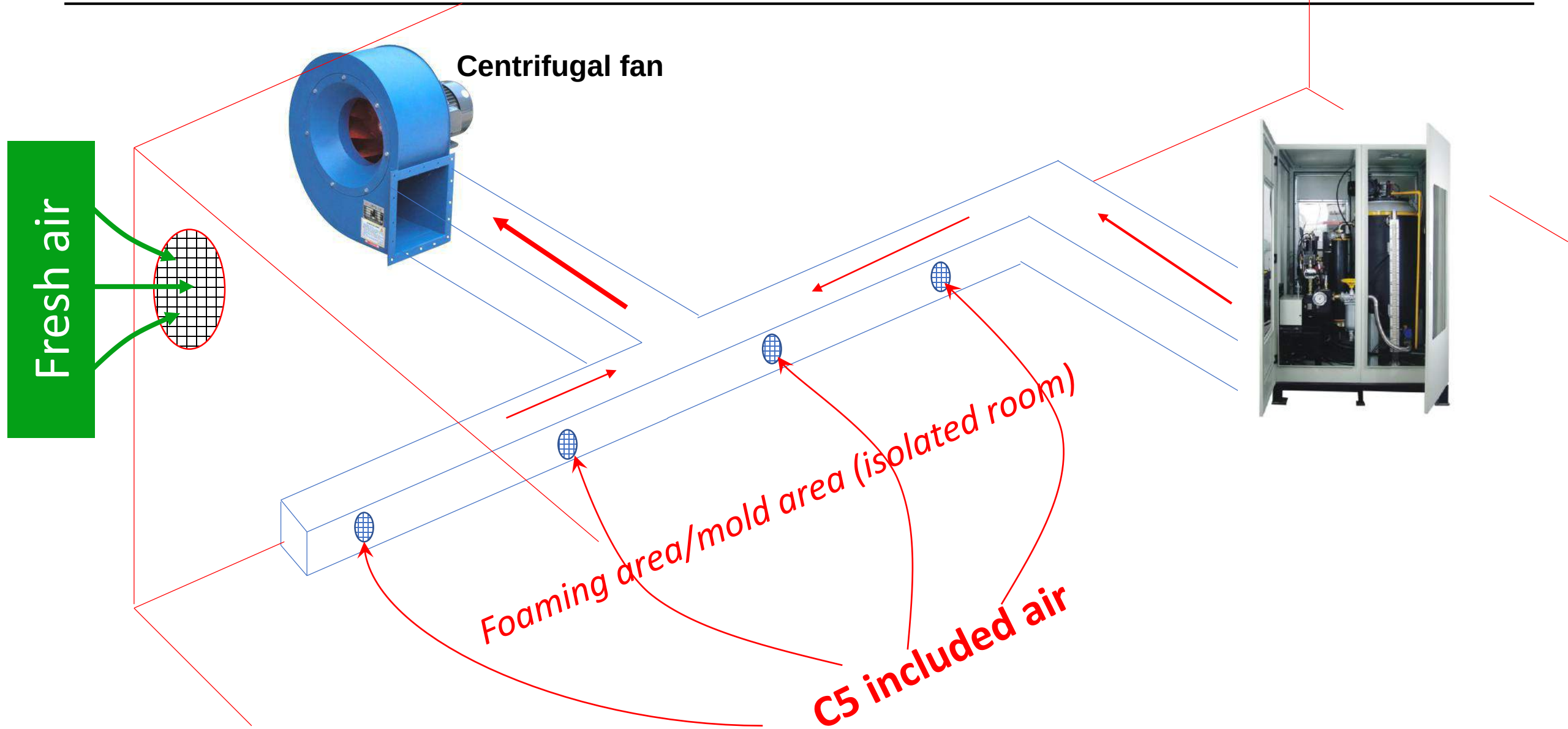


Ventilation is **NOT** big fan in workshop

Right Ventilation

NEXT PAGE

Ventilation design



Risk Control Methods

Warehouse and storage tank

Check List

- N_2 protection in the drum or not?
- Temperature control in warehouse?
- c-Pentane separation in low temp?
- c-Pentane content in system?

Safe Operation Skills

- Grounding before open the drums;
- Avoid to use part of drum materials;
- When use up, keep the drum open and put it in open space for a while;
- If possible, isolate pre-blended polyol in warehouse or build barriers.
- Ensure N_2 supply if storage tank is used. Build barriers for storage tank.

Scratch the coating

Necessary Equipment

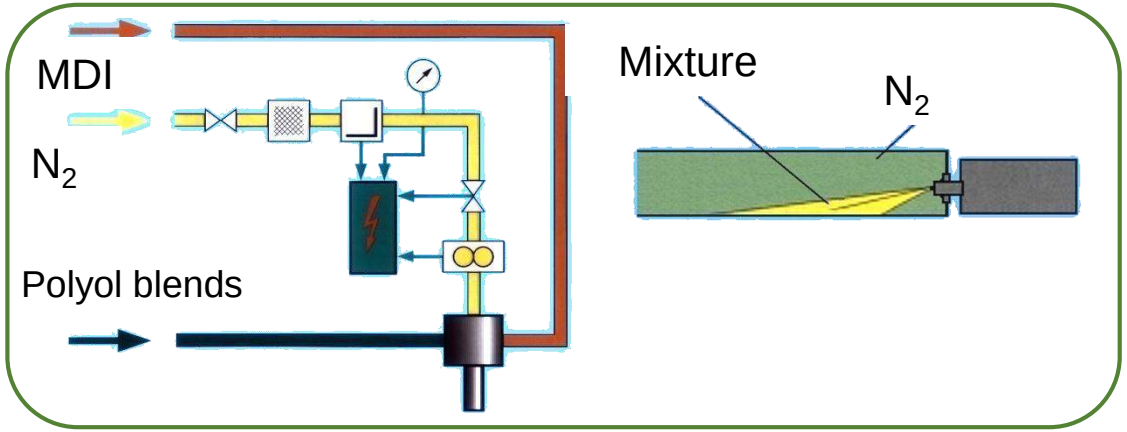
- Ventilation system
- Detectors and alarm system
- Anti-fire equipment
- Sand
- Grounding system

Risk Control Methods

Foaming Machine

Injection Area

High risk points



Safety Checking

- ◆ Working tank sealing, N_2 supply?
- ◆ Isolation of polyol working tank?
- ◆ N_2 injection before material injection?
- ◆ Grounding of mold and products?

Safe Operation Skills

- ■ Check the ventilation regularly
- ■ Calibration of detectors and alarm system
- ■ N_2 injection time vs. cavity size

Necessary Equipment

- ☐ Ventilation system
- ☐ Detectors and alarm
- ☐ Anti-fire equipment
- ☐ Sand
- ☐ Grounding system

Detectors and Alarm System

THE LAST SAFETY GUARD

Input

Output

Output

Ventilation system

Power control for related equipment

IMPORTANT THINGS

- UPS for the system !
- Calibration!
- Alarm (sound + light) is good
- Ventilation feedback is good

- 1st Level alarm: 20% LEL (CP concentration: 1.5%*20%)
- 2nd level alarm: 40% LEL (CP concentration: 1.5%*40%)

Risk Assessment/Ventilation

Example: Disconti. Panel

Panel size(L/W/T): 8m/1.2m/0.15m

V_{cavity}= 8m×1.2m×0.15m=1.44 m^3

PU foam injection weight=1.44m^3 × 50kg/m^3=72kg

Gas loss during foaming=72kg × 3.0%=2.16kg (max.)

C5 emission=2.16kg/3=0.72kg (max.)

C5 emission time: 3-5min (short emission time)

Emission rate=0.72kg/3min=0.24kg/min (max.)

Demolding time: 30min (enough ventilation time)

Ventilation Design

$$Q_{min} = \frac{G_{max} \cdot f}{K_{perm} \cdot LEL \cdot C} \cdot \frac{T}{293}$$

$\boldsymbol{Q_{min}}$: Minimum ventilation capcity, m^3/min

$\boldsymbol{G_{max}}$: Maximum C5 emission rate (g/min)

$\boldsymbol{LEL}$: Lower explosion limit of C5 (1.5%)

$\boldsymbol{f}$: Air flow quality factor, data from 1-5

$\boldsymbol{K_{perm}}$: Safety factor, normally use 0.5

$\boldsymbol{C}$: Vapor density of C5 at 20ºC (g/m^3)-2915

$\boldsymbol{T}$: Maximum workshop temperature (K)

Thanks for Your Attention!

-ZHANG PENG
-Mobile：+86-18802102150
-E-mail：zhangp8@139.com

Equipment Application For Alternatives

Hangfa Maron Mechatronics Engineering, Chengdu, China

CONTENTS

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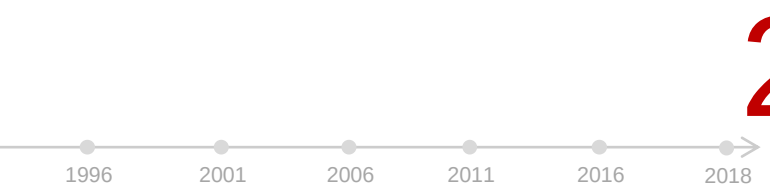
01 | Introduction To Maron



Polyurethane Foaming Machine

- Design
- Development
- Manufacturer

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HCFC-141b PU Foaming Machine

2006

Cyclopentane PU Foaming Machine

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Large-scale Production in 2009

- Continuous design accumulation
- Continuous renewal of ideas
- Continuous investment in R&D

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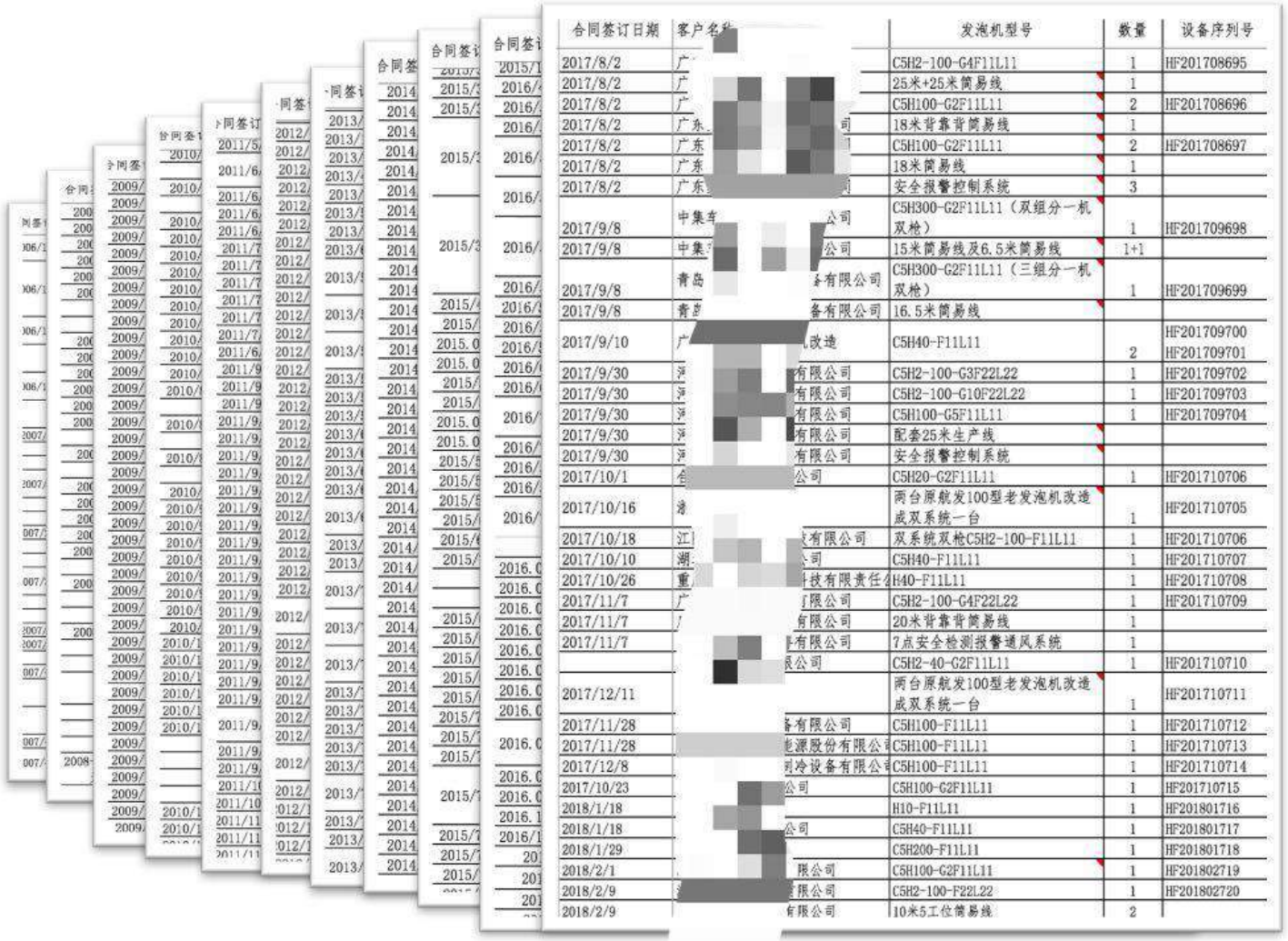

合同签订日期	客户名称	发泡机型号	数量	设备序列号
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2017/8/2	广	25米+25米简易线	1	
2017/8/2	广	C5H100-G2F11L11	2	HF201708696
2017/8/2	广东	18米背靠背简易线	1	
2017/8/2	广东	C5H100-G2F11L11	2	HF201708697
2017/8/2	广东	18米简易线	1	
2017/8/2	广东	安全报警控制系统	3	
2017/9/8	中集车 公司	C5H300-G2F11L11（双组分一机双枪）	1	HF201709698
2017/9/8	中集 公司	15米简易线及6.5米简易线	1+1	
2017/9/8	青岛 有限公司	C5H300-G2F11L11（三组分一机双枪）	1	HF201709699
2017/9/8	青 有限公司	16.5米简易线		
2017/9/10	广 改造	C5H40-F11L11	2	HF201709700 HF201709701
2017/9/30	沪 有限公司	C5H2-100-G3F22L22	1	HF201709702
2017/9/30	沪 有限公司	C5H2-100-G10F22L22	1	HF201709703
2017/9/30	沪 有限公司	C5H100-G5F11L11	1	HF201709704
2017/9/30	沪 有限公司	配套25米生产线		
2017/9/30	沪 有限公司	安全报警控制系统		
2017/10/1	全 公司	C5H20-G2F11L11	1	HF201710706
2017/10/16	通	两台原航发100型老发泡机改造成双系统一台	1	HF201710705
2017/10/18	江 有限公司	双系统双枪C5H2-100-F11L11	1	HF201710706
2017/10/10	湖 公司	C5H40-F11L11	1	HF201710707
2017/10/26	重 技有限责任	H40-F11L11	1	HF201710708
2017/11/7	广 限公司	C5H2-100-G4F22L22	1	HF201710709
2017/11/7	有限公司	20米背靠背简易线	1	
2017/11/7	有限公司	7点安全检测报警通风系统	1	
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2017/11/28	有限公司	C5H100-F11L11	1	HF201710712
2017/11/28	源股份有限公	C5H100-F11L11	1	HF201710713
2017/12/8	冷设备有限公	C5H100-F11L11	1	HF201710714
2017/10/23	公司	C5H100-G2F11L11	1	HF201710715
2018/1/18		H10-F11L11	1	HF201801716
2018/1/18	公司	C5H40-F11L11	1	HF201801717
2018/1/29		C5H200-F11L11	1	HF201801718
2018/2/1	限公司	C5H100-G2F11L11	1	HF201802719
2018/2/9	限公司	C5H2-100-F22L22	1	HF201802720
2018/2/9	有限公司	10米5工位简易线	2	

903 projects

from 2007 - 2018

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Service Delivered To Over **258** companies

Haier

Hisense 海信 创新就是生活

AUCMA 澳柯玛

Wanbao 万宝

美菱 Meiling

XINGX 星星

TCL

Homa 奥马

GREE 格力

美的 Midea

CHiQ CHANGHONG 长虹

Skyworth 创维

CIMC 中集物流

USATON® 阿诗丹顿

Vanward 万和

芬尼 PHNIX

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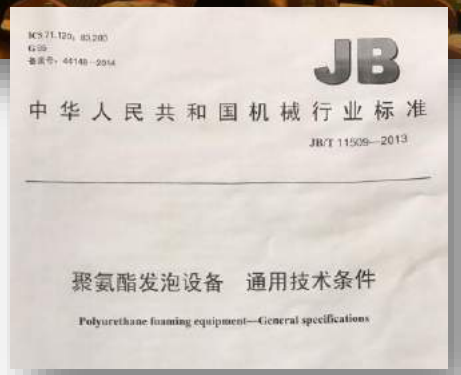
- Team consists of top technical talents from German, China and United States of America

- Invited by the United Nations Development Programme (UNDP) to share the technology of cyclopentane foaming

- Invited by the Ministry of Environmental Protection to participate in the symposium on HCFC green low carbon alternative technology in China PU foam industry

- Chief Drafter of the PU China Machinery Industry Standard



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Cost effective product has been delivered to different nations and areas

India
China
Malaysia
Pakistan
Vietnam
Turkey
Egypt
Ethiopia

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CONTENTS

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02 | Cyclopentane Foaming Machine Design

- ISOCYANATE Unit
- POLYOL Unit
- Hydraulic Unit
- Mixing Head Unit
- Chiller Unit
- Electrical Control System

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02 | Cyclopentane Foaming Machine Design

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Efficient Mixing Head

Double Tilted Injection for mixing
Self-cleaning, prevent being jammed
Transition section, prevent being polluted

High Compatibility

Modular design
Easy maintenance
Compatible with spare parts of various companies

Perfect Sealing

Magnetic coupling
Save raw material

Explosion Proof & Safe

Cyclopentane monitoring alarm system
Intelligent ventilation system

Intelligent Electrical Control

Siemens Profinet field network structure
Network bus connection simplifies the layout
Reduce cable wear and improve stability

Precise Metering

Close-loop control, high precision flow control
Precise material temperature control, reduce the effect of temperature difference on foaming
Pressure detection at both ends, high precision pressure control

Risk Warning System

Multiple warning systems: flow, temperature, material ratio, pressure etc.

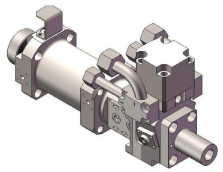
High reliability

Mutual backup design, some component failures do not affect production, manufacturers do not need to stop work

02 | Cyclopentane Foaming Machine Design

ISOCYANATE Unit

1. Non-Jacketed 330 liter carbon steel and pressurized tank
2. Stainless tube heat exchangers with 2.0m² area
3. Self cleaning filter
4. High pressures HYDROMATIK REXROTH pump A2VK
5. Frequency converter and magnetic coupling (option)



POLYOL Unit

1. Anlistatig room for polyol tank group
2. Non-jacketed 330 liter carbon steel and pressurized tank
3. Visual magnetic level indicator
4. Stainless tube heat exchangers with 2.0m² area
5. Pentane safety valve
6. Self cleaning filter
7. EX-I,EX-D components
8. High pressures HYDROMATIK REXROTH pump A2VK
9. Frequency converter and magnetic coupling(option)

Hydraulic unit

1. Hydraulic pressure can be displayed and set on touch screen
2. High and low limit hydraulic pressure setting
3. Open modular design and easy maintenance

Mixing Head Unit

1. L-shaped carbon steel body
2. 1 hydraulically operated self-cleaning piston
3. 1 hydraulically operated and fast moving mixing spools Complete withre-circulation grooves
4. 2 injection nozzles
5. 2 solenoid valves for the head operation
6. 2 proximity switches for the sequence control
7. Spacer to avoid oil contamination of the PU chemicals

Chiller unit

1. Capacity:3HP
2. Cooling capacity:7000kcal/h
3. CHL2-30 stainless water pump with 20M 3.3M³/h capacity

Electrical Control System

1. Omron PLC and AD module for the centrel control
2. 8 touch screen HMI for operation interface
3. English/chinese display with instant automatic alarm and fault handling, fault locating and alarm,more than 100 history alarm saved.
4. All the parameters can be set and adjusted accurately and Conveniently
5. Parameter setting for security 4 level protection
6. Dynamic monitoring of materials percentage and flow

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02 | Cyclopentane Foaming Machine Design

Re-design of the PU foaming machine for alternatives-Cyclopentane

- New mixing head for efficient mixing
- Sealing and explosion-proof design
- Intelligent control system

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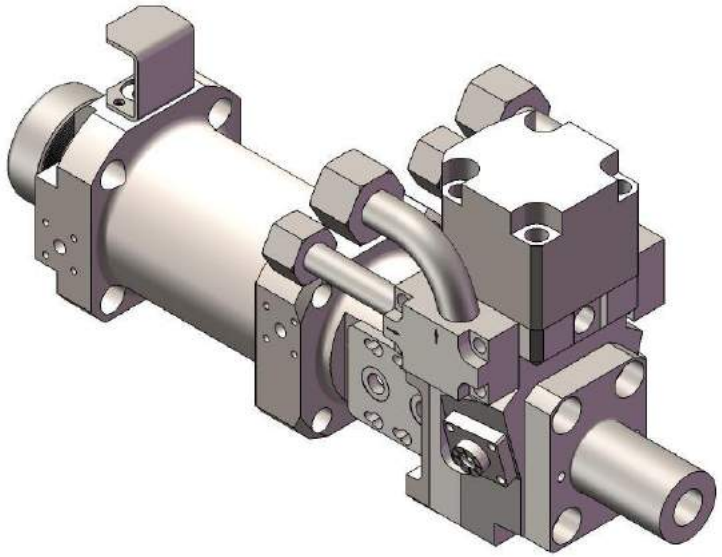
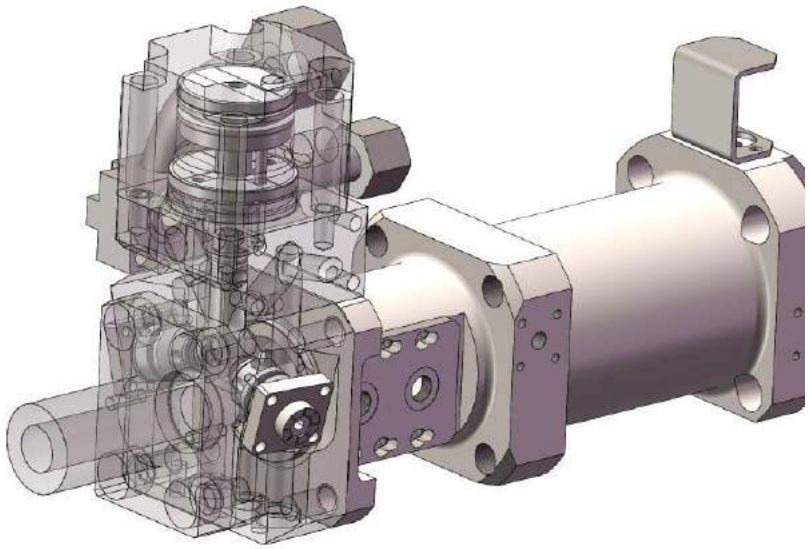
02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing





New mixing head guarantees the mixing efficiency

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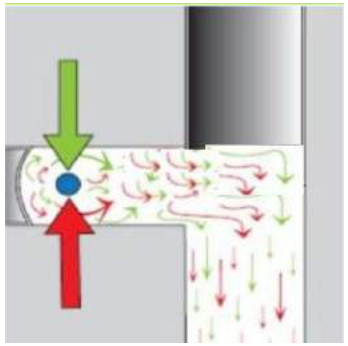
02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing



Traditional design

Using Cyclopentane

Foaming without efficient mixing
Affect the quality of refrigerator

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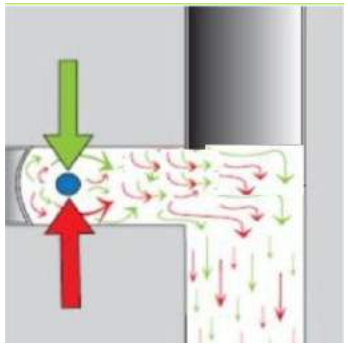
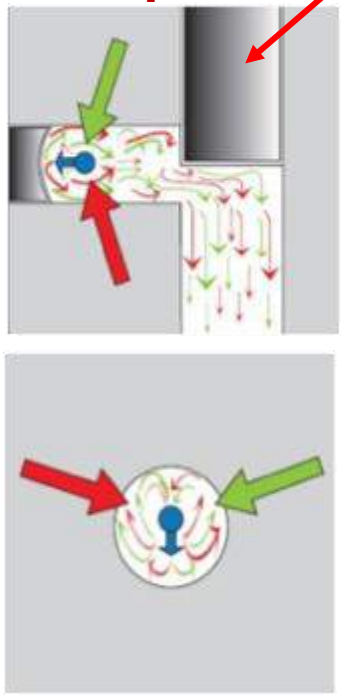
02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing



Re-design



2. Adjustable mixing chamber to improve the mixing efficiency

1. Double Tilted Injection

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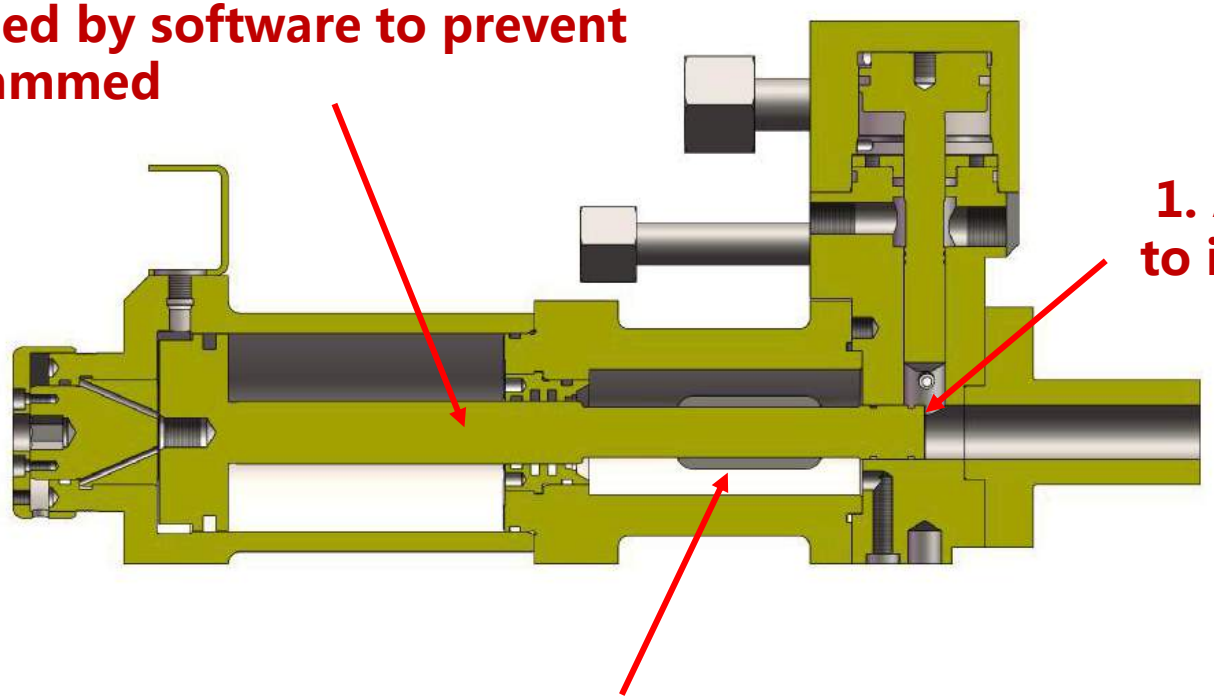
02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing

4. Upper piston retention controlled by software to prevent being jammed



1. Adjustable mixing chamber to improve the mixing efficiency

3. Self-cleaning piston with lubrication to prevent being jammed

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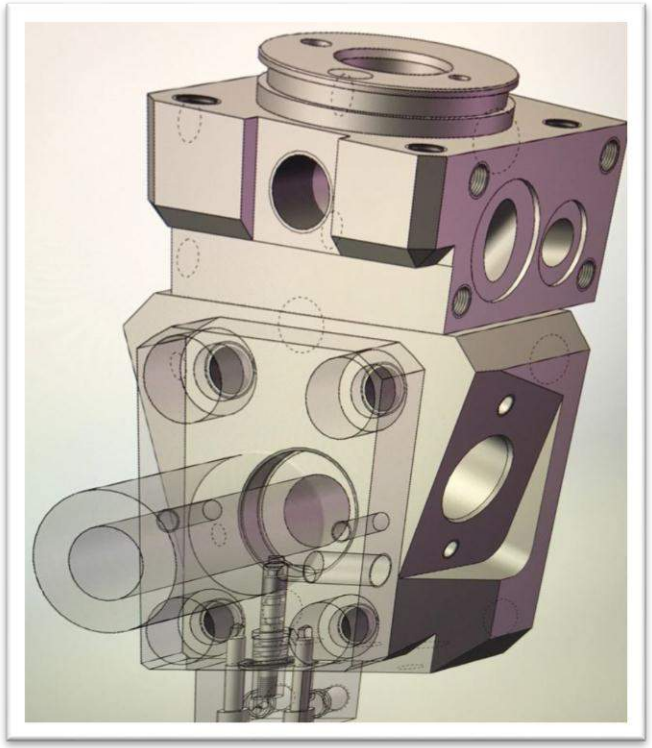
02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing



Upgrade our capability to manufacture new mixing head

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02 | Cyclopentane Foaming Machine Design

--- New mixing head for efficient mixing

Before Re-design

Mixing efficiently

After Re-design

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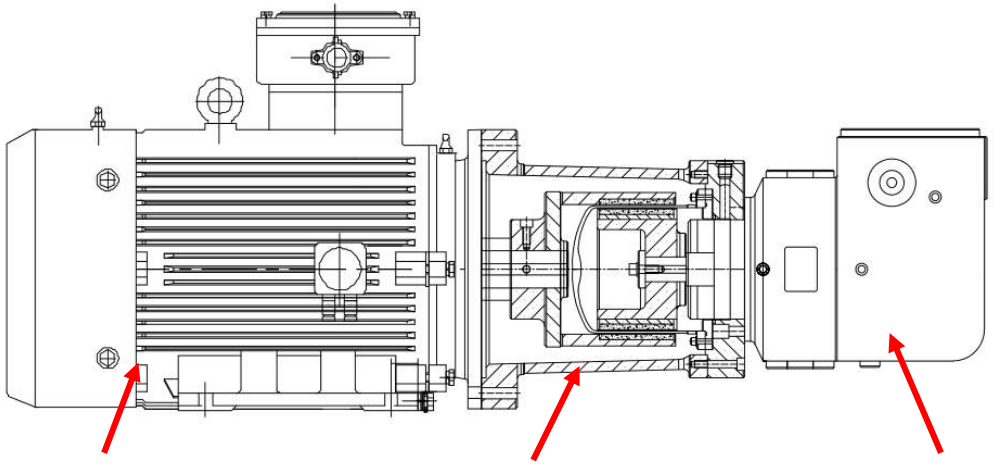
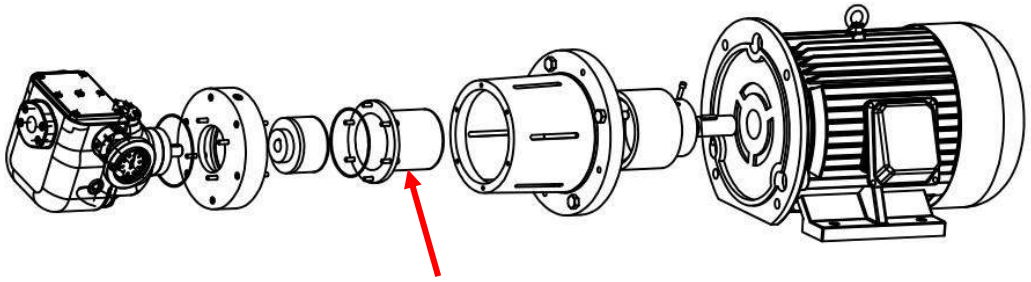
02 | Cyclopentane Foaming Machine Design

--- Sealing and explosion-proof design

Magnetic coupling used in Metering Unit to prevent leakage





Nonmetallic isolating cover to prevent eddy current heating

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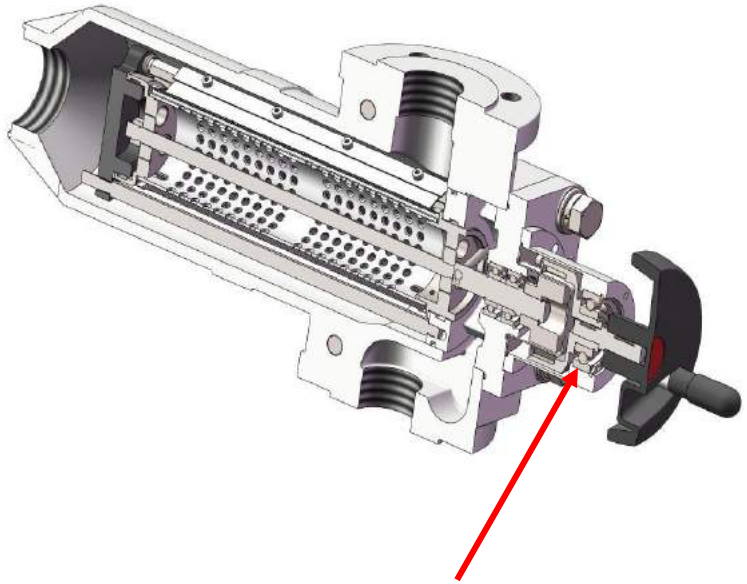
02 | Cyclopentane Foaming Machine Design

--- Sealing and explosion-proof design

Magnetic coupling used in Material Filter



Magnetic coupling

Magnetic coupling used in Material Tank

Mixing system in material tank

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02 | Cyclopentane Foaming Machine Design

--- Sealing and explosion-proof design

- Antistatic polycarbonate transparent door enclosure
- Cyclopentane gas monitoring sensor
- Explosion-proof stirrer motor
- Fireproof valve

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02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

- Touch screen interface
- Real-time Process Monitoring & Setting
- Closed-loop automatic control
- Intelligent Alarm System

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02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

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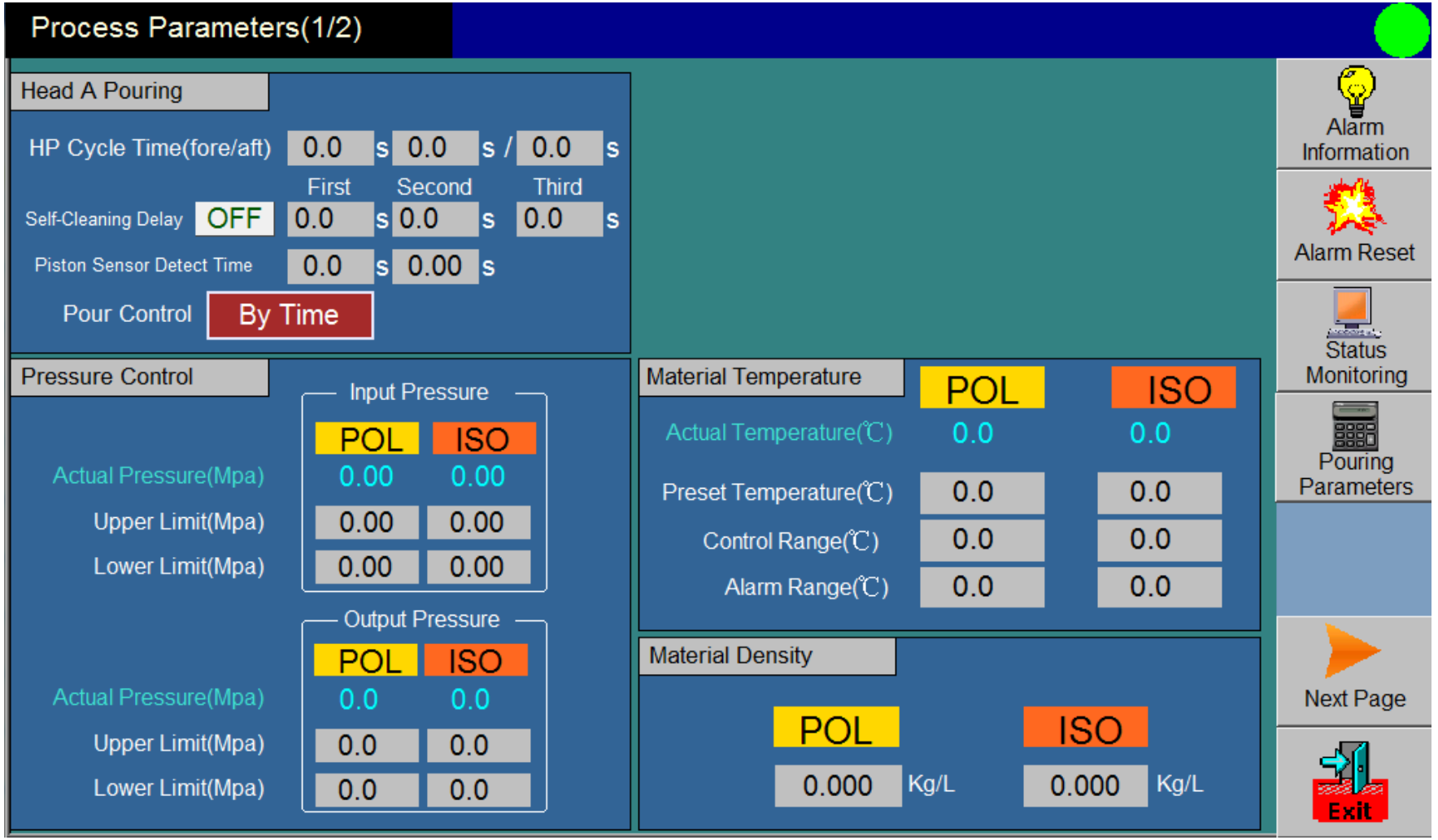
02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System



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02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

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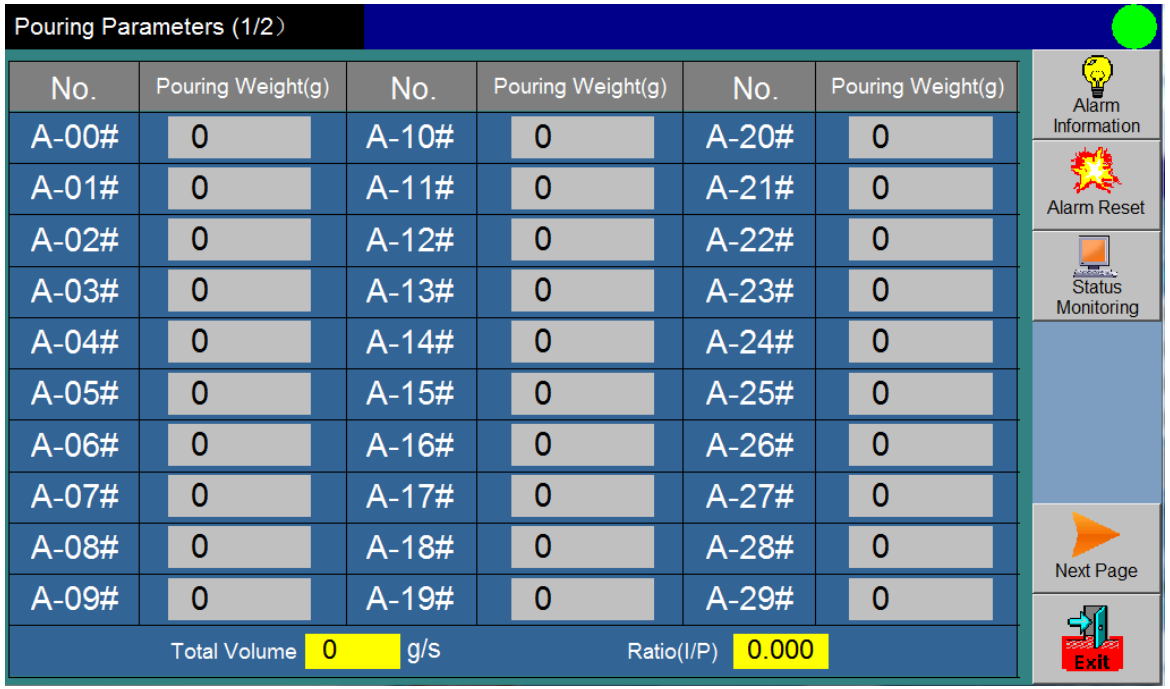
02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System



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02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

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02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

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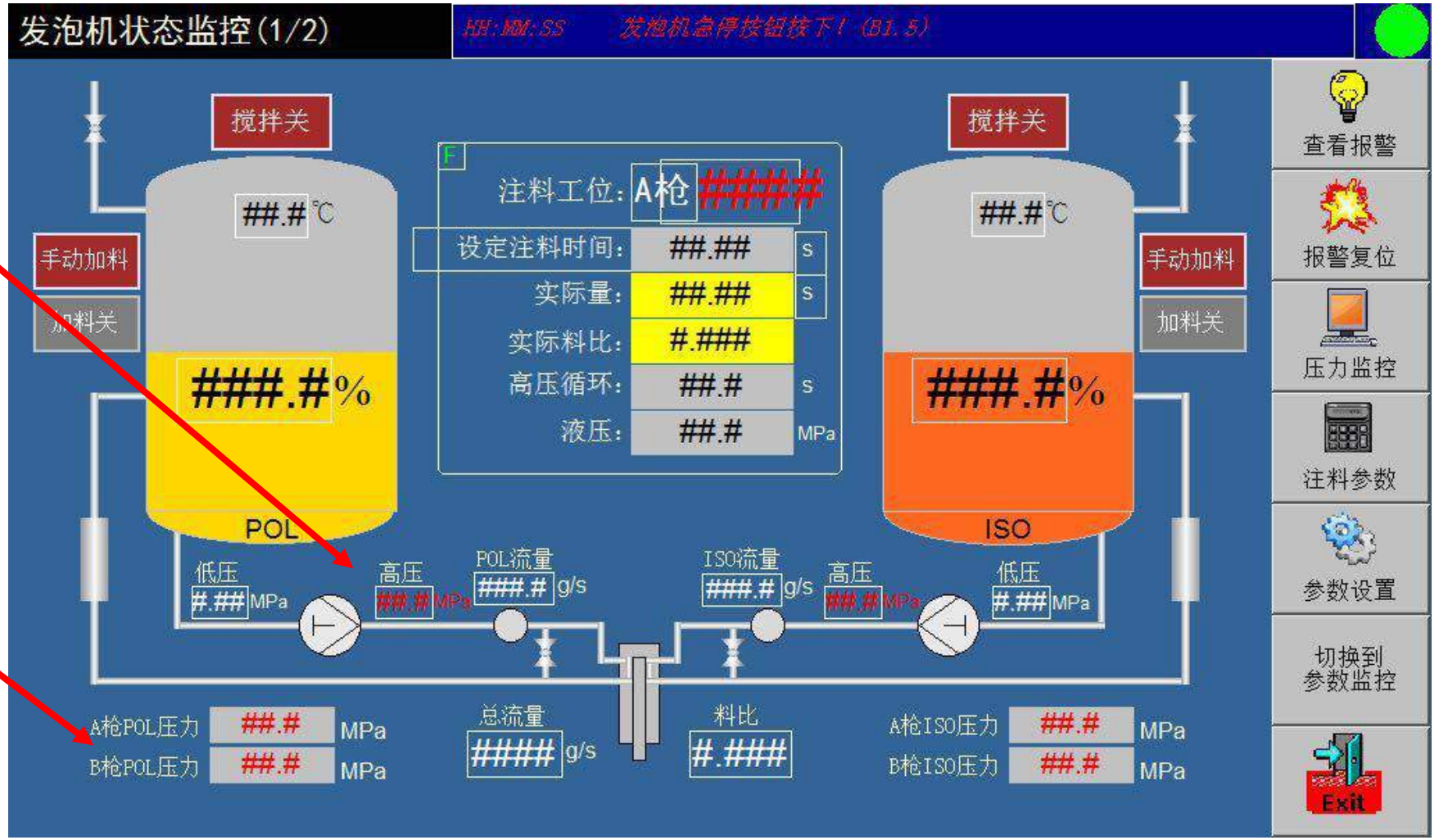
02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

Pump outlet pressure real-time monitoring

One more set of head pressure transmitters



02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System

One more set of mixing head pressure real-time monitoring

- Siemens S7-1200 PLC control
- Profinet field network structure, ET200SP distributed IO module to remotely control POL unit, hydraulic unit, chiller unit, mixing head and operating unit
- Achieve long-distance data transmission, greatly simplifying the structure of electrical circuits
- The network bus connection repalces the complicated multi-core flexible cable, avoids signal errors and faults caused by cable fatigue breakage, simplifies line connection, and improves system operation speed and reliability.
- PLC can monitor the injection pressure data at the end of the mixing gun
- Replace the mechanical pressure gauges with the anti-crystallization digital display

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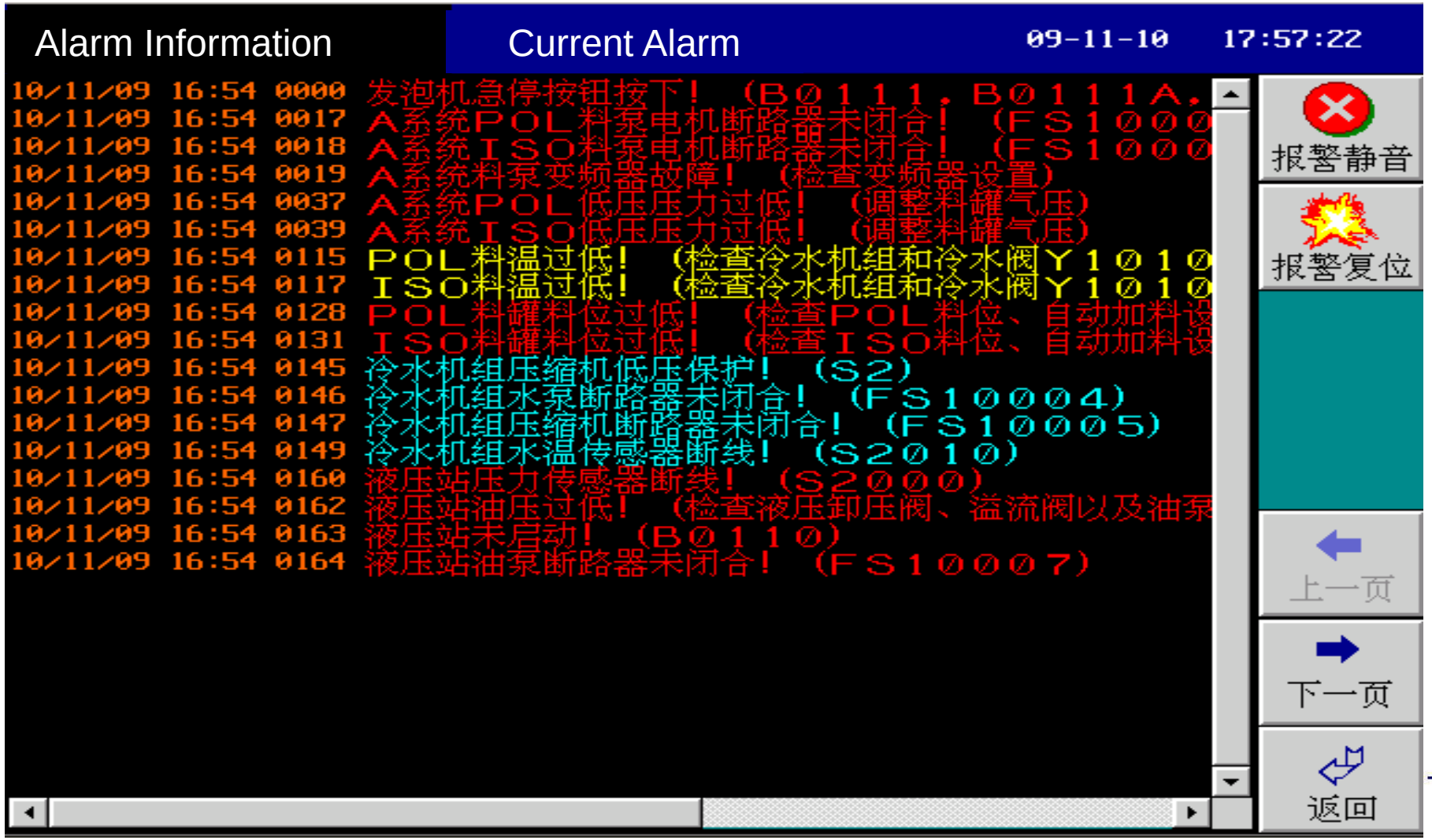
02 | Cyclopentane Foaming Machine Design

--- Intelligent Control System



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CONTENTS

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03 | Cyclopentane Safety Warning System

Independent C5 Safety Alarm & Control System consists of :

- Independent electrical control cabinet
- C5 catalytic sensor
- Buttons and indicator lamps
- Exhaust fan (5.5kw/7.5kw)
- Exhaust Pipeline

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03 | Cyclopentane Safety Warning System

The main control panel controls the following operation:

- Reasonable distribution of C5 gas sensor, including foaming machine, production line，pouring position
- Monitor different level of concentration of C5 gas
- Alarms of different risk levels
- Automatic Ventilation System (Hierarchical startup of ventilation system according to different risk levels)
- Leakage detection control
- Power control(using Uninterrupted Power Supply)UPS is used in the design of the control system to ensure that safety measures are not compromised.

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03 | Cyclopentane Safety Warning System

The control panel can show real-time readout of C5 percentage detected by the sensors and set the quantity, in percentage, of the pre-alarm and alarm thresholds

Pentane sensor control card has two alarm level (20% and 40%)

1 audio-alarm system to differentiate the occurred alarm levels

1 set of polychromatic light indicators to visualize warning signal of the operation condition of the foaming line:

Three levels of the alarm system:

Clear or Blue for no alarm (normal operation of the foaming line)

Yellow for pre-alarm (level 2)

Red for alarm (level 1)

The settings depend on the situation:

20% LEL pre alarm, forced ventilating starts

40% LEL alarm, production line closed in emergency automatically.

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03 | Cyclopentane Safety Warning System

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CONTENTS

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04 | Application Case

Main Application Area Of Cyclopentane Foaming Machine

- Refrigerator　Commercial Refrigerator　Freezer
- Water Heater
- Panel　PU Sandwich Panel　Heat Insulation Pipe
- Cold Chain Logistics　Refrigerated Truck　Ice Box
- Automotive Interior　Car Seating　Car Head Cushion

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04 | Application Case

Haier

Cyclopentane Foaming Machine For Refrigerator

Qingdao, China , 2017

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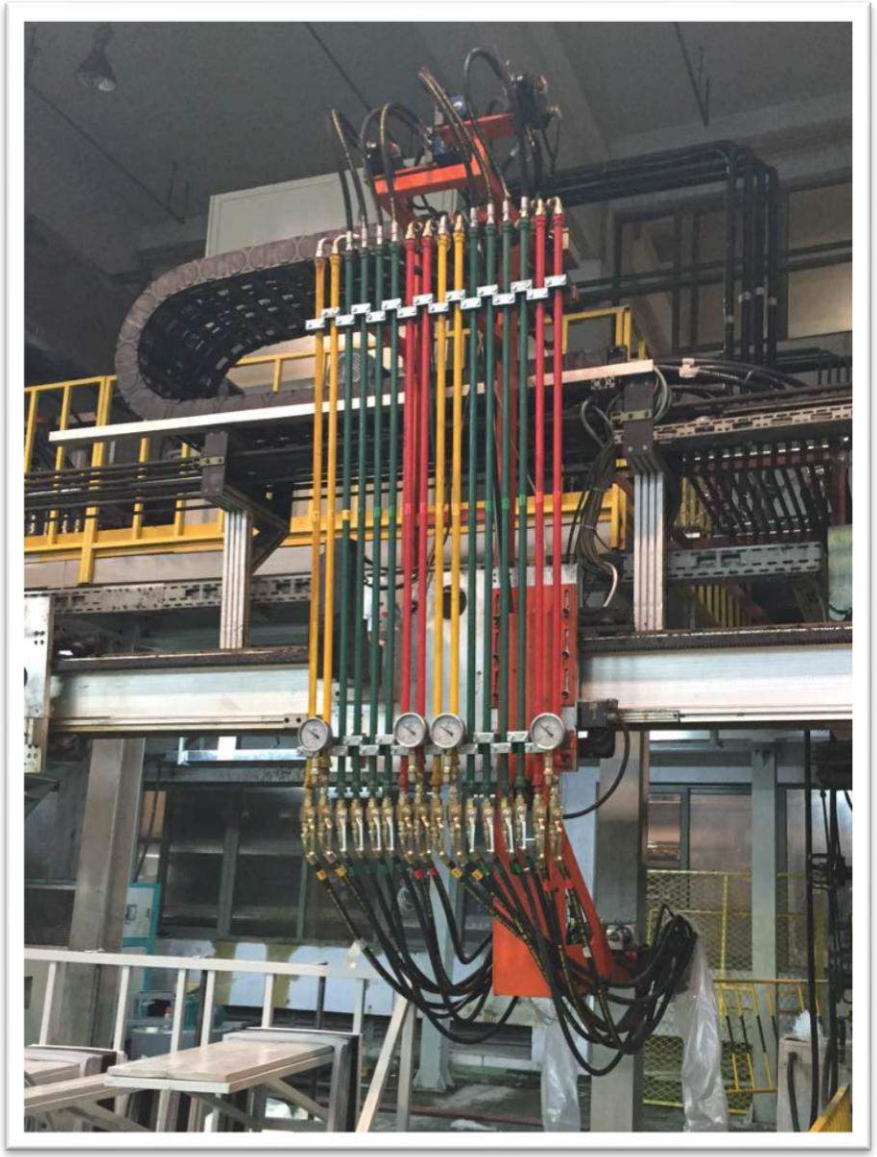
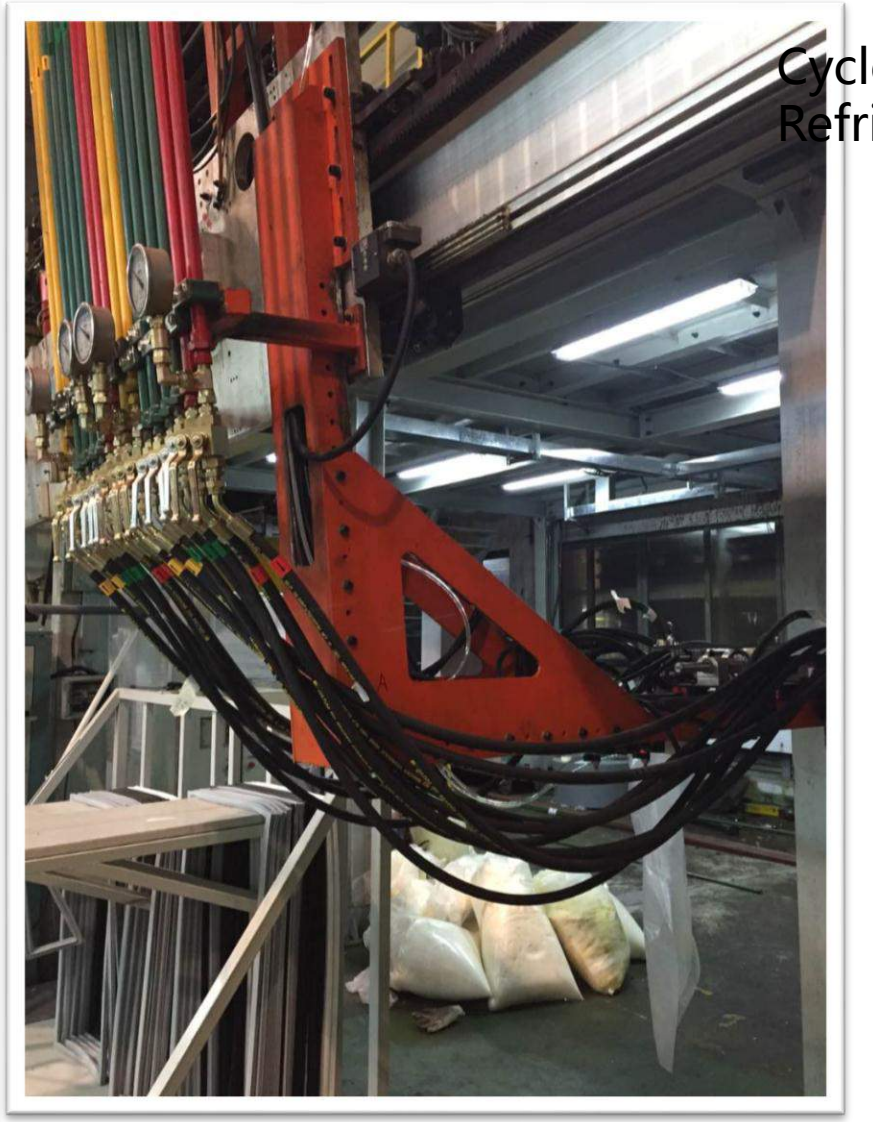
04 | Application Case



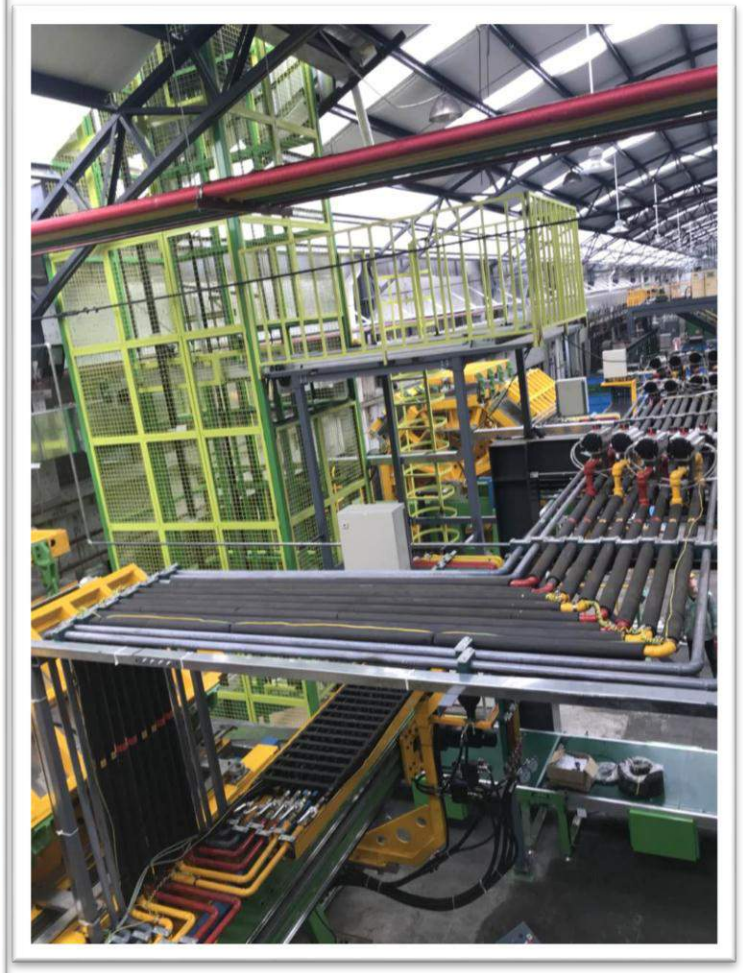


Cyclopentane Foaming Machine For Refrigerator

Qingdao, China , 2017

04 | Application Case

Hisense 海信
创新就是生活



Cyclopentane Foaming Machine For Hisense Refrigerator and Freezer

Guangzhou, China，2017

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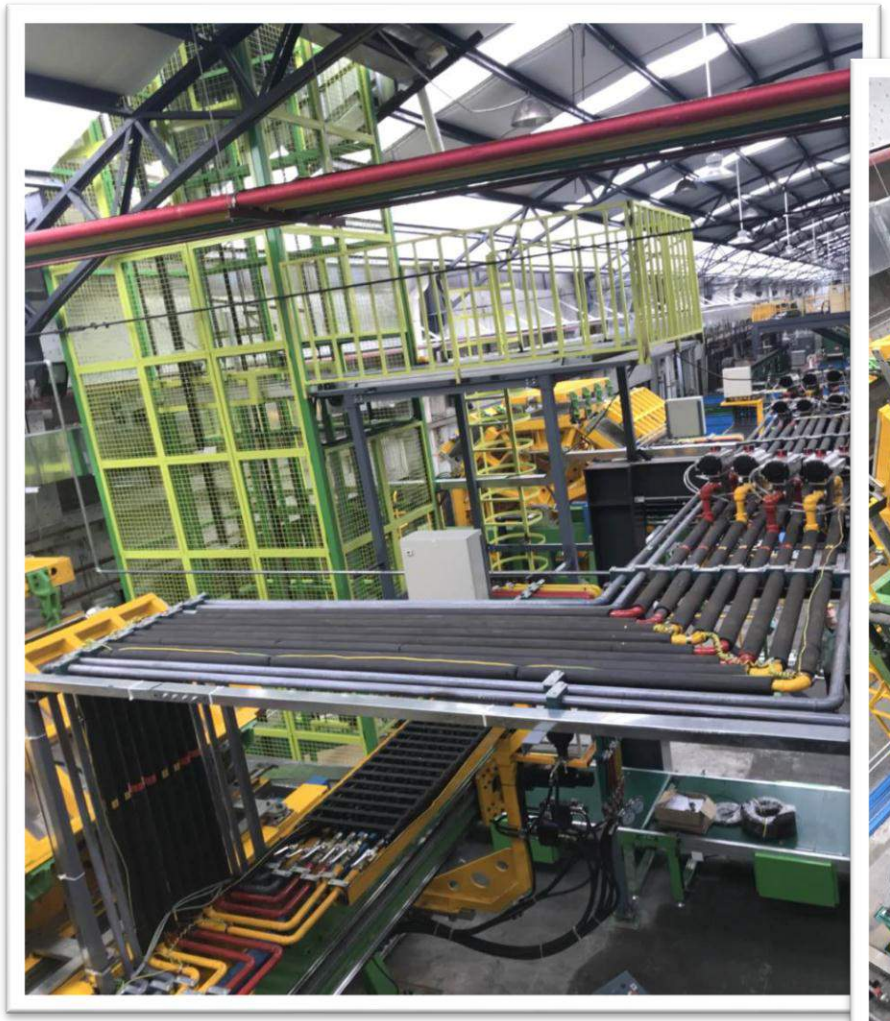
04 | Application Case

Cyclopentane Foaming Machine For Hisense Refrigerator and Freezer

Guangzhou, China，2017

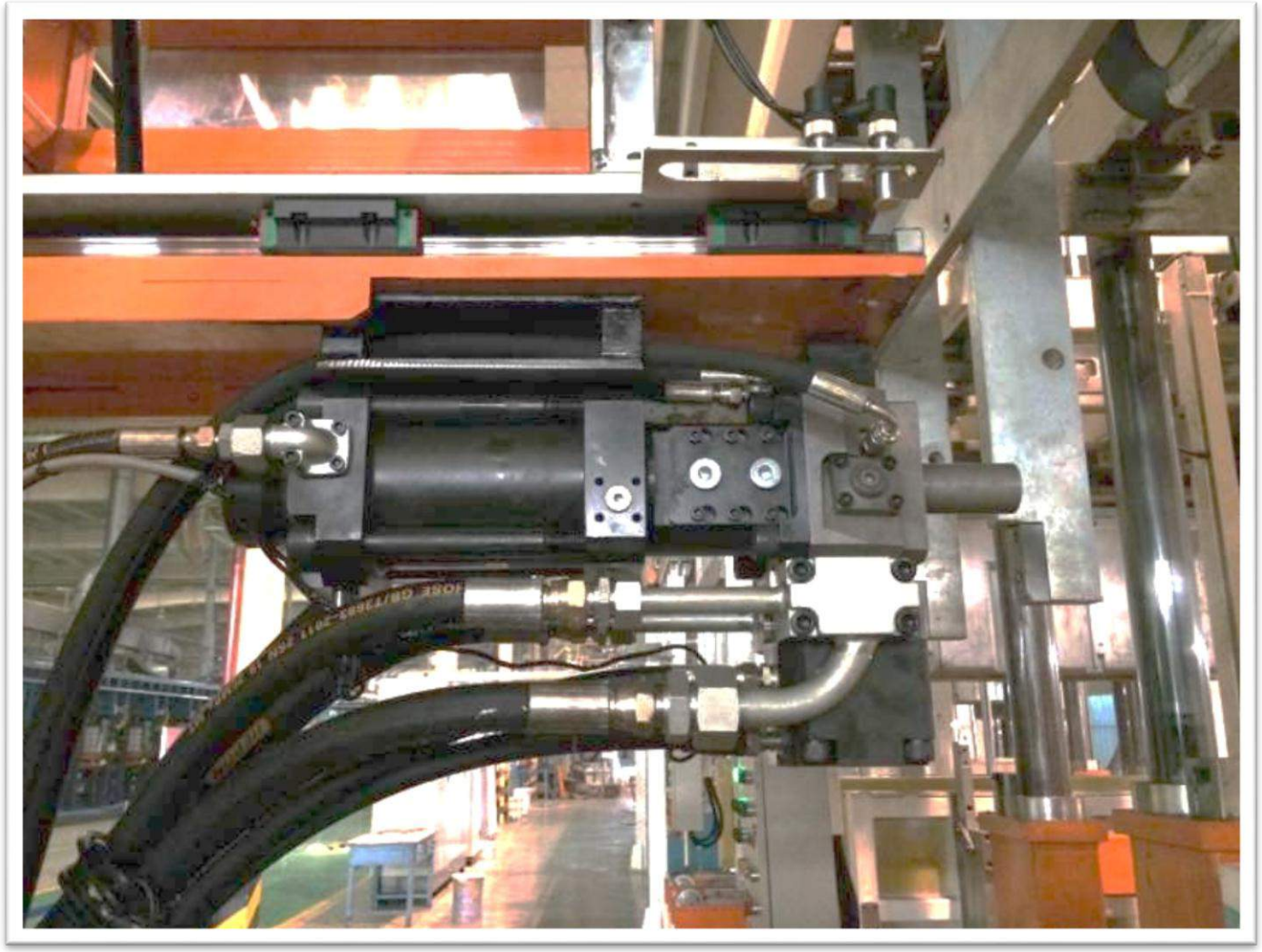
04 | Application Case



Cyclopentane Foaming Machine For Hisense Refrigerator and Freezer

Guangzhou, China，2017

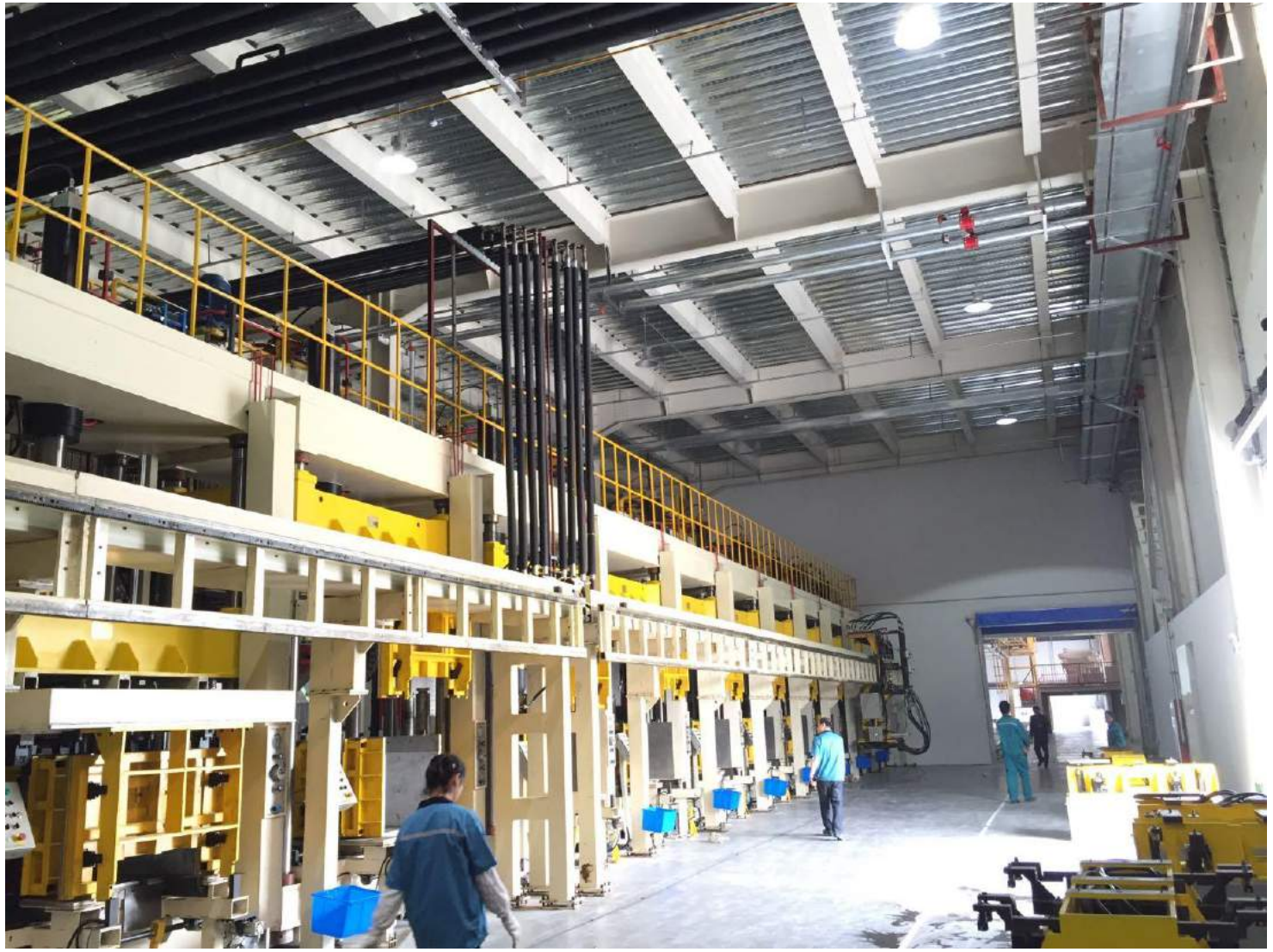
04 | Application Case



Cyclopentane Foaming Machine For Hisense Refrigerator and Freezer

Guangzhou, China，2017

04 | Application Case



Cyclopentane Foaming Machine For Meiling Refrigerator and Freezer

Hefei, China，2017

04 | Application Case

Cyclopentane Foaming Machine For Meiling Refrigerator and Freezer

Hefei, China，2017

04 | Application Case

Cyclopentane Foaming Machine For Meiling Refrigerator and Freezer

Hefei, China，2017

Polyurethane Technologies

04 | Application Case

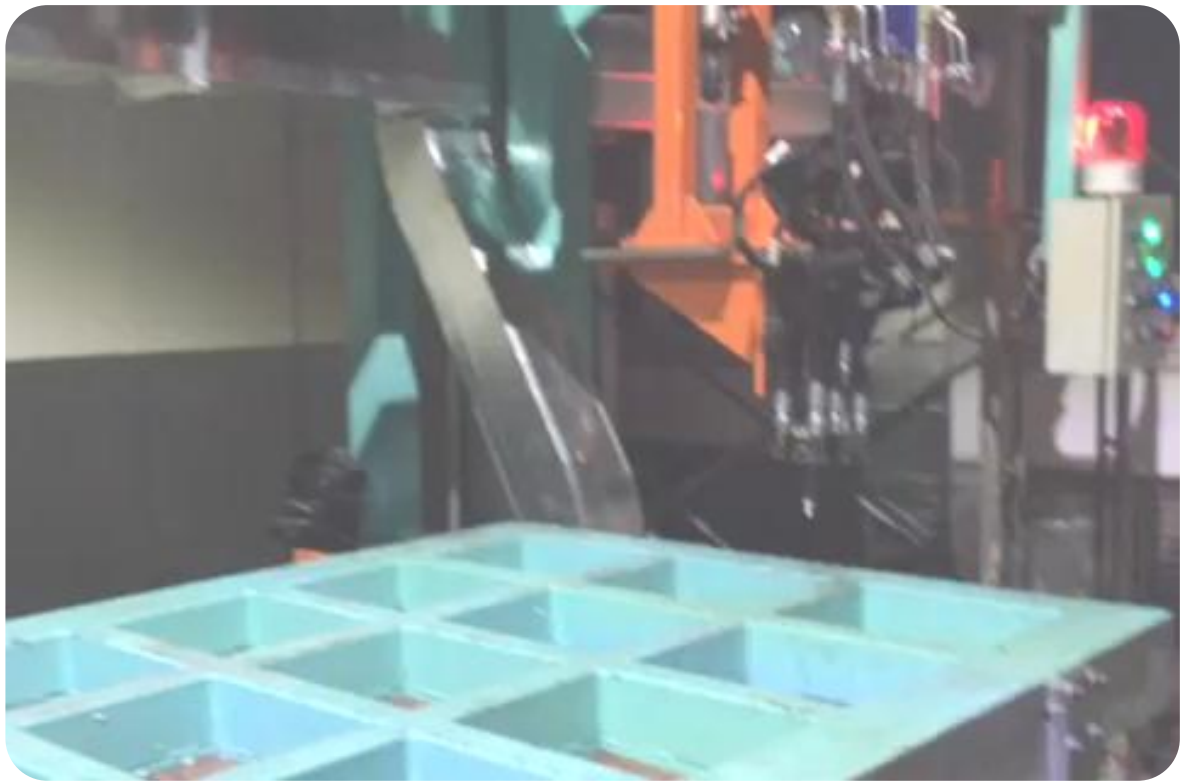
Cyclopentane Foaming Machine For Meiling Refrigerator and Freezer

Hefei, China，2017

04 | Application Case

Cyclopentane Foaming Machine For Meiling Refrigerator and Freezer

Hefei, China，2017



04 | Application Case

CIMC 中集冷链

Cyclopentane Foaming Machine For CIMC Cold Chain Logistics Panel

Qingdao, China, 2017

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04 | Application Case

CIMC 中集冷链

Cyclopentane Foaming Machine For CIMC Cold Chain Logistics Panel

Qingdao, China, 2017

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04 | Application Case

CIMC 中集冷链

Cyclopentane Foaming Machine
For CIMC Cold Chain Logistics

Discontinuous Panel Line

Qingdao, China, 2017

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04 | Application Case

CHANGHONG RUBA
—Creating Easy Life—
Be a part of hundred million smiles!

In Pakistan, 2017

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04 | Application Case

Guangdong Xingxing Refrigrators

Polyurethane Technologies

04 | Application Case

For Commercial Refrigerator In Ethiopia, Africa ,2017

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04 | Application Case

Maron precise small flow foaming machine（15 g/s - 150 g/s)

For Continuous Panel Line

Combine ISO tank & POL tank in one C5 enclosure to save cost and space

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04 | Application Case

Maron precise small flow foaming machine（15 g/s - 150 g/s)

For Continuous Panel Line

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04 | Application Case

Maron foaming machine for Vehicle Interior

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04 | Application Case

Maron foaming machine for Vehicle Interior

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04 | Application Case

Maron foaming machine for Vehicle Interior

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04 | Service

1. Customized alternative technical solution, according to the products, production and budget of our customer, help our clients save money.

2. Installation and Commissioning

3. Operation training & Maintenance training

4. Localized service team with spare parts, timely response to customer

5. Remote online monitoring on foaming machine status, can tailor the program online to our client`s specific needs.

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THANK YOU

Hangfa Maron Mechatronics Engineering Co. Ltd

Email: info@maron.cn
Cellphone: +86 13808094583
Website：www.maron.cn

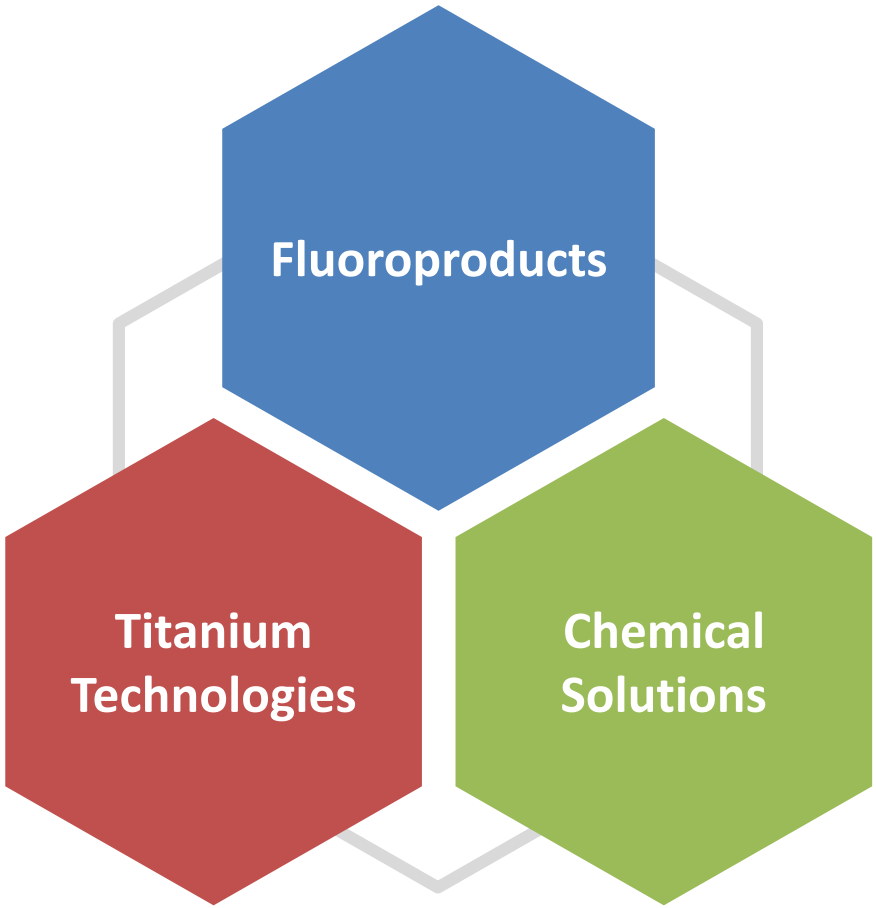
Chemours™

Opteon™ 1100: The Next Generation Blowing Agent for a Sustainable Future

We unleash the power of chemistry, working hand-in-hand with our customers

- We are a new company with over 200 years of history, created from DuPont's performance chemical businesses
- We help create a **colorful**, **capable**, and **cleaner** world through the power of chemistry
- We create new applications and industry-defying solutions that have a greater market impact

• The Chemours Company: *Created from DuPont's Performance Chemicals Businesses*



Market Leader

In safe production & manufacture of performance chemicals. Combining leading products, applications expertise, and market-shaping chemistry

#1 in market share of fluoropolymers

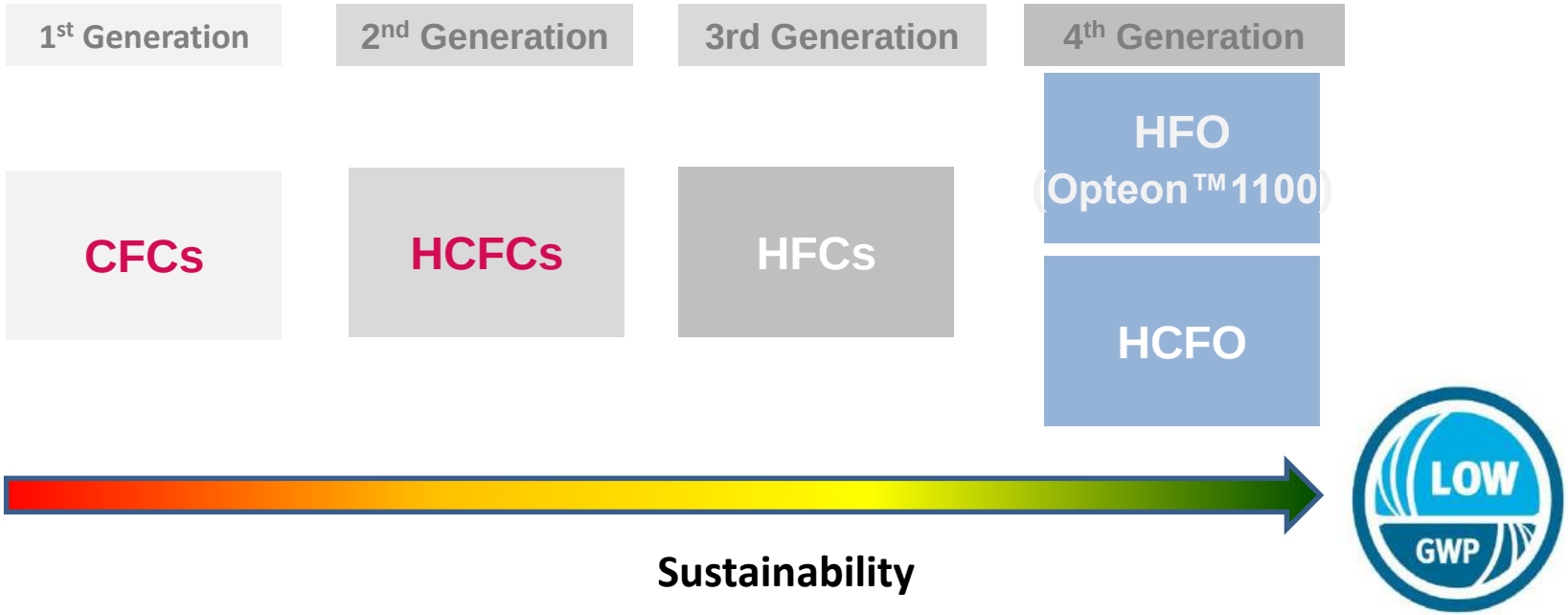
#1 brand of TiO2 in the market

#1 in global supply capacity of low global warming potential products

Global Regulatory Drivers

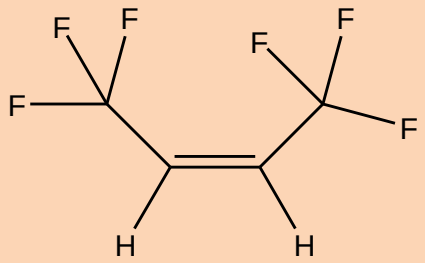
Sustainability

Since the early 1990's fluorochemical blowing agents have transitioned to more sustainable options with no Ozone Depletion Potential (ODP) and now low Global Warming Potential (GWP).



TM of Chemours

Opteon™ 1100: *The Next Generation Foam Blowing Agent*



Opteon™ 1100

Key Attributes:

- **Low Global Warming Potential (GWP =2)**
- **Boiling Point (33 °C)**
- **Chemical Stability**
- **Insulation Performance (λ 10.7 mW @ 25 °C)**
- **Low Diffusivity**
- **Nonflammable**
- **Favorable Toxicity Profile**

Winner of the 2017 CPI Innovation Award

Opteon™ 1100: *The Next Generation Foam Blowing Agent*

Key Application Areas:

- **Spray Polyurethane Foam (SPF)**
- **Appliance Foam**
- **Hot Water Heater Foam**
- **Board Stock**
- **Integral Skin**

Spray Foam

Appliances

Integral Skin

Blowing Agent Comparison

Blowing Agent	ODP	GWP	Boiling Point (°C)	Lambda @ 25 °C (mW/m K)	Flammability
Opteon™ 1100	0	2	33	10.7	None
HCFC-141b	0.11	782[a]	31	9.7	None
HFC-245fa	0	858[a]	15	12.7	None
HFC-365mfc	0	804[a]	40	10.6	Yes
HCFO-1233zd	~0[c]	1	19.5	10.5	None
Methylal	0	< 3	42	14.5	Yes
Methyl Formate	0	< 25	32	15.8[b]	Yes
Cyclopentane	0	11	49	13	Yes

a: (100-yr ITH) AR 5

b: *Extrapolated from literature data(17.7 mW @ 100 °C)*

c: No impact on ozone layer depletion and is commonly referred to as zero

Chemours Opteon™ 1100: *Elastomer Compatibility*

	Elastomers			
RATING				
	% LINEAR SWELL		HARDNESS	
0 - COMPATIBLE;	<= 11	AND	<= 11	
1 - BORDERLINE; WHEN	>10	OR	>10	
2- INCOMPATIBLE; WHI	>10	AND	>10	

Compatibility Rating - Plastics
0 = Best; when weight gain<1 and physical change = 1
1= Borderline; when weight gain>1 and <10 or physical change = 2
2= Worst; when weight gain>10 or physical change = 3
Physical Change
1= No change
2= Surface change (dulled or crazed)
3= Destroyed or dissolved

14 day study	**25 °C**	**100 °C**
	Opteon™ 1100	Opteon™ 1100
D	**Compatibility rating**	**Compatibility rating**
Elastomer Material		
Neoprene C1276-70	**0**	**0**
Epichlorohydrin YB 146-75	**0**	**0**
Butyl B0612-70	**0**	**1**
EPDM E0893-80	**0**	**0**
Fluorosilicone	**2**	**2**
HNBR nitrile N1173-70	**2**	**2**
NBR nitrile NA151-70	**1**	**1**
Fluorocarbon FKM V0747-75	**2**	**2**
Neoprene C0873-70	**0**	**0**
Viton A401C	**2**	**2**
Viton GF 600S	**2**	**2**

Chemours Opteon™ 1100: *Plastic Compatibility*

	Elastomers			
RATING				
	% LINEAR SWELL		HARDNESS	
0 - COMPATIBLE;	<= 11	AND	<= 11	
1 - BORDERLINE; WHEN	>10	OR	>10	
2- INCOMPATIBLE; WHI	>10	AND	>10	

Compatibility Rating - Plastics
0 = Best; when weight gain<1 and physical change = 1
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Physical Change
1= No change
2= Surface change (dulled or crazed)
3= Destroyed or dissolved

14 day study	**25 °C**	**100 °C**
	Opteon™ 1100	Opteon™ 1100
D	**Compatibility rating**	**Compatibility rating**
Elastomer Material		
Plastic Material		
Polyester (thermoplastic) Bexloy V-978	**1**	**1**
Nylon Resin -Zytel 330	**0**	**0**
Torlon Polymer (polyamide-imide plastic)	**0**	**0**
Ryton polymer (polyphenylene sulfide)	**0**	**0**
PEEK (Ketaspire 820 NT)	**0**	**0**
Nylon 6.6 polymer plastic (Zytel 101)	**0**	**0**
PTFE	**0**	**1**

Benefits for Conversion

Opteon™ 1100 does NOT require investment for:

- **Pressure-rated tanks, piping, or containers for transportation or storage**
- **Changes in materials of construction**
- **Flammability or explosion proofing equipment**

Applications

Spray Polyurethane Foam (SPF)

Opteon™ 1100's attributes make it ideal for SPF applications:

- **Ultra Low GWP (2)**
- **Boiling point (33 °C)**
- **High Chemical Stability**
- **Low Thermal Conductivity**
- **Very Low Diffusion Coefficient**
- **Nonflammability**
- **Non VOC**
- **Excellent Toxicity Profile**

Austin House Opteon™ 1100 Application Update: *"5 Star Green Building Rating Awarded"*

In January 2015, Opteon™ 1100 was successfully incorporated into a commercial medium density spray foam formulation and applied on a large scale project in Austin, TX.

<u>Highlights include:</u>

- **Excellent application behavior**
- **Superior thermal insulation performance (Overall R 26)**
- **Comparable physical properties**
- **Good yield characteristics**

Property of elev8 Builders

Chemours™ BASF We create chemistry elev8 DESIGN + BUILDERS IBP INSTALLED BUILDING PRODUCTS

Applications

Appliance Insulation Foam

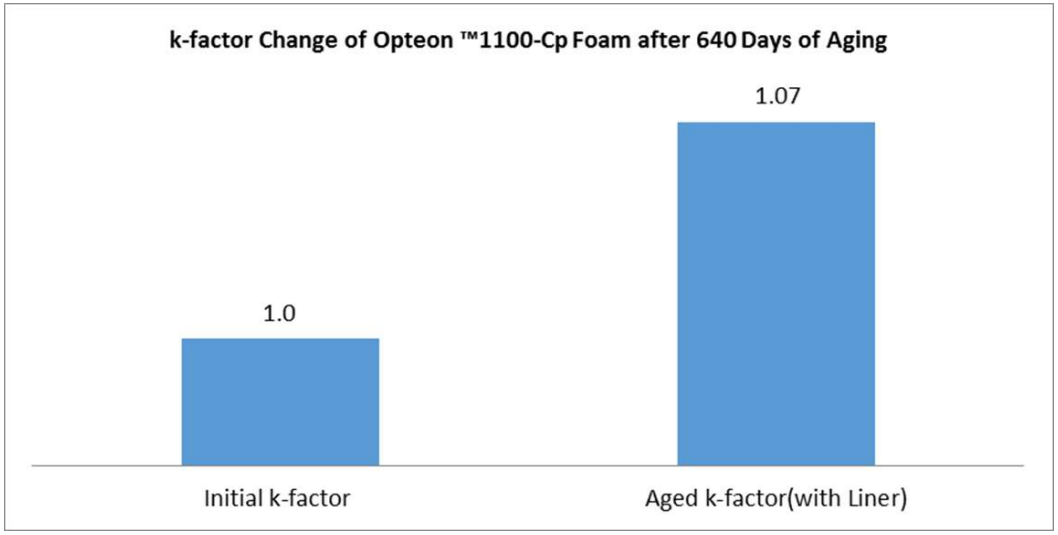
Opteon™ 1100's attributes make it ideal for appliance applications:

- **Ultra Low GWP (2)**
- **High Chemical Stability**
- **Low Thermal Conductivity**
- **Very Low Diffusion Coefficient**
- **Powerful Synergies with Hydrocarbons**
- **Good Material Compatibility**
- **Excellent Toxicity Profile**

Appliances

Opteon™ 1100: Appliance Applications

- ✓ **Excellent blowing agent retention**
- ✓ **Formulation stability**
- ✓ **Compatible with HIPS liners, even with HC blends.**
- ✓ **Compatible with ABS liners, HC blends show mixed results.**



Acknowledgements

Productos Eiffel
www.Eiffel.com.mx

The BASF Corporation
www.spf.basf.com

Elev8 Builders
www.elev8builders.com

Installed Building Products (IBP)
www.installedbuildingproducts.com

Disclaimer

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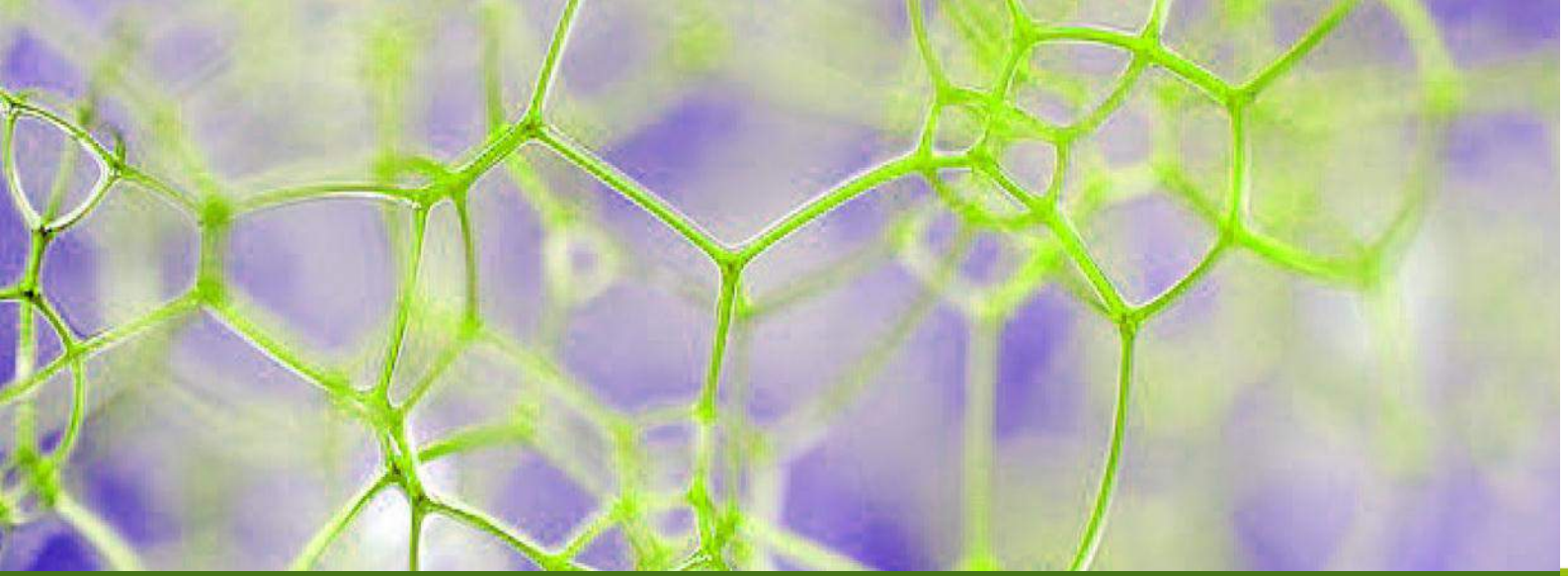
Chemours™



SOLVAY

asking more from chemistry®

Solkane® 365

Foam Blowing Agents

IXOL® B251 & M125

Flame Retardants

Safety & Handling& Application

SOLKANE®

01/10/2018

Content

- The Importance of Safety & Handling
- Solvay's Commitment
- Blowing Agents & Flame Retardant General Guidelines
- SOLKANE® – Your best Choice
- Product Properties
- Bulk Packaging Guidance
- Tank Guidance
- Drum Packaging Guidance
- Key Takeaways

Why is Safety & Handling important?

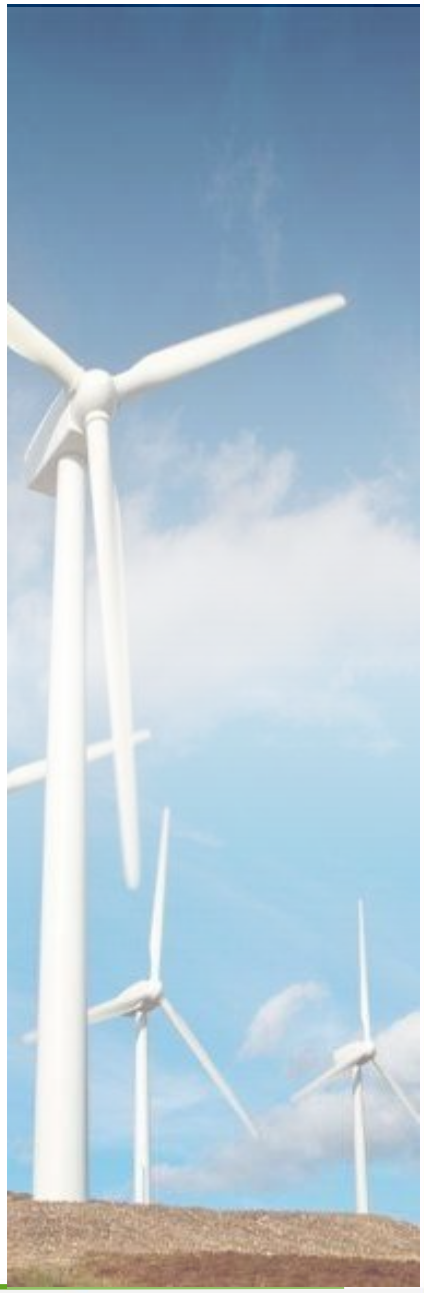
- Safety includes the avoidance of any danger coming from the transport, storage, withdraw, usage and disposal of SOLKANE® products for people and environment
- SOLKANE® Products are highly specialized and designed for outstanding product characteristics.
- Following approved Safety and Handling guidelines minimize the risk of any danger.
- This presentation shall give you guidance regarding possible risks and how to avoid them to achieve the best result for your final product and for the people and environment

An ambitious Sustainable Development policy

Five priority objectives

SOLVAY way

1. To achieve excellence in safety, health and occupational hygiene for everyone on our sites
2. To realize an increasing share of our sales in markets or with portfolio of activities meeting the requirements of sustainable development
3. To continuously improve the performance of our technologies, processes and products so to avoid injuries and limit their environmental impact throughout the lifecycle of our products
4. To reduce greenhouse-gas emissions, energy and water consumption, and negative impacts on soil, water and air quality, as well as the use of resources
5. To develop rich and balanced social dialogue



Blowing Agents & Flame Retardants

General Guidelines

Basic Risk Consideration during handling of Blowing Agents and Flame Retardants

- Follow the recommendations from the MSDS
- Keep your working area clean and tidy
- Wear your personal protection equipment e.g. gloves and goggles.
- Do not smoke while handling or working with Blowing Agents or Flame Retardants
- Avoid any open flames in your handling area, ground your equipment against electrostatic charge
- Ensure that your working space is well ventilated

SOLKANE® 365/227

Safety data

Characteristic	Unit	SOLKANE® 365	SOLKANE® 227	SOLKANE® 365/227 93:07	SOLKANE® 365/227 87:13
Boiling point	°C	40	-17	30	24
Vapour pressure (20 °C)	mbar	400	3900	700	880
Flash point	°C	< - 27	-	-	-
Lower explosion limit	% (v/v)	3.6	-	3.6*	3.6*
Upper explosion limit	% (v/v)	13.3	-	13*	13*
Minimum ignition energy	mJ	10.4	-	>> 1300	>> 1300
Auto ignition temperature	°C	594	-	594	594

*under worst case fractionation conditions

Why SOLKANE® – Best Choice!

Easy & Safe Handling

- **SOLKANE® 365 Blends are non-flammable liquids**
  - The boiling point is above standard processing temperatures (HFC-245fa Bp is 15 °C).
  - In hot weather climates, the vapour pressure is low – limiting product loss vs HFC-245fa
- **SOLKANE® 365 Blends are packaged in standard drums**
  - HFC-245fa ships in pressurized gas containers and cylinders
- **Polyol system optimization**
  - Polyol systems can be optimized to show no flashpoint

Why SOLKANE® – Best Choice!

Best performance

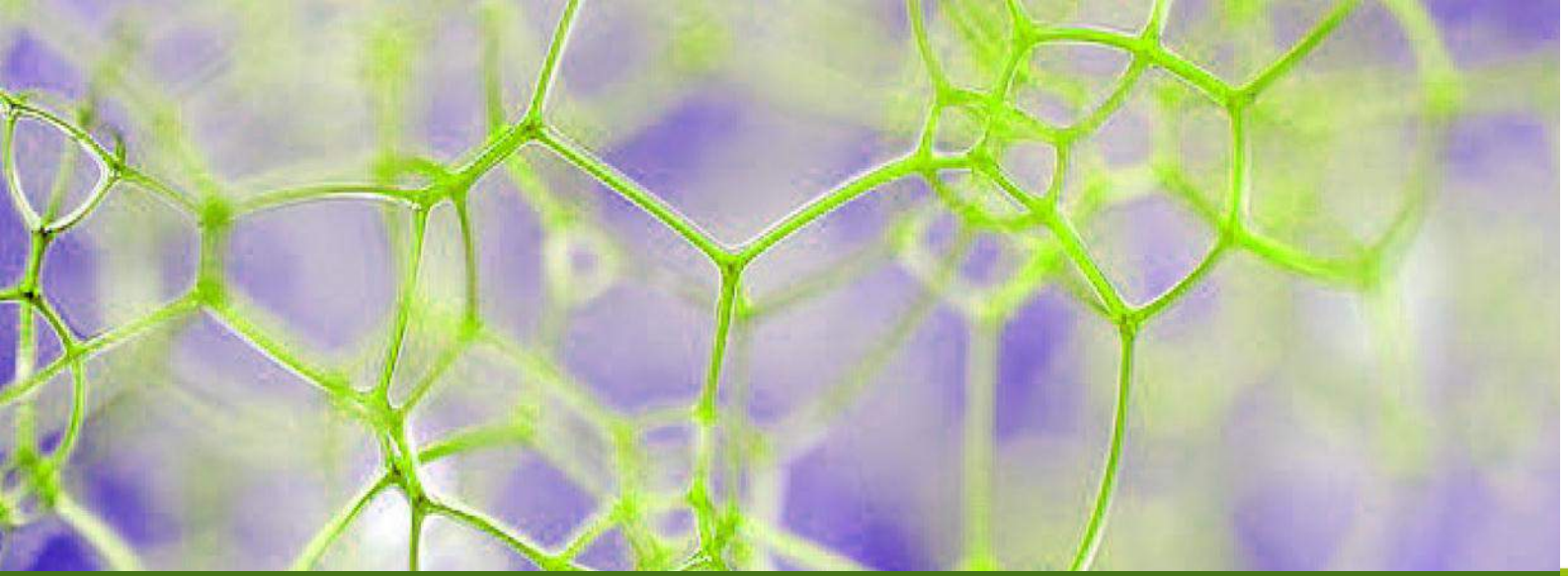
- **Best fire test results**
  - Compared to pentanes, SOLKANE® 365 blends are significantly better due to the fluorine content in the molecule.
- **Best insulation value**
  - Based on standard aged time values and beyond
  - Less energy needed to heat & cool buildings, appliances – resulting in direct environmental CO_2 savings
- **Easy conversion of HCFC-141b systems**
  - Closest match to HCFC-141b of available replacements
  - Existing equipment can be used
  - Processing for end users match HCFC-141b

Why SOLKANE® – Best Choice!

Economic Advantage

- **Improved mechanical foam properties vs HCFC-141b**
  - Less foam needed to achieve the same stability.
  - Cost savings.

- **Unbeatable versatility**
  - SOLKANE® 365mfc blends perfectly with all blowing agents for more advanced customized blowing agent formulations.



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SOLKANE® 365 blends
IXOL® Products
Product Properties

SOLKANE®

01/10/2018

Comparative Physical properties

	HCFC-141b	HFC-365mfc	HFC-365/227 93:7	HFC-365/227 87:13	HFC-245fa	c-pentane
Structure	$CCl_2F\text{-}CH_3$	$CF_3\text{-}CH_2\text{-}CF_2\text{-}CH_3$	$CF_3\text{-}CH_2\text{-}CF_2\text{-}CH_3$ $CF_3\text{-}CHF\text{-}CF_3$	$CF_3\text{-}CH_2\text{-}CF_2\text{-}CH_3$ $CF_3\text{-}CHF\text{-}CF_3$	$CF_3\text{-}CH_2\text{-}CF_2H$	
Mol.-Weight	116.9	148.1	149.5	150.9	134	70
Boiling Point [°C]	31.7	40.2	30	24	15.3	49.5
Vapour pressure at 20 °C [bar]	0.6	0.4	0.7	0.9	1.2	0.35
Lambda [gas at 25 °C]	9.5	10.6	10.7	10.7	12.2	12.0
Flash point [°C]	none	-27	none	none	none	-37
Flammability limits [% by volume]	7.4 - 17.7	3.6 - 13.3	3.6 - 13.3*	3.6 - 13.3*	none	1.4 - 8.3
MIE [mJ]	20 000	10.4	>> 1000	>> 1000	-	0.54

* based on pure Solkane® 365mfc

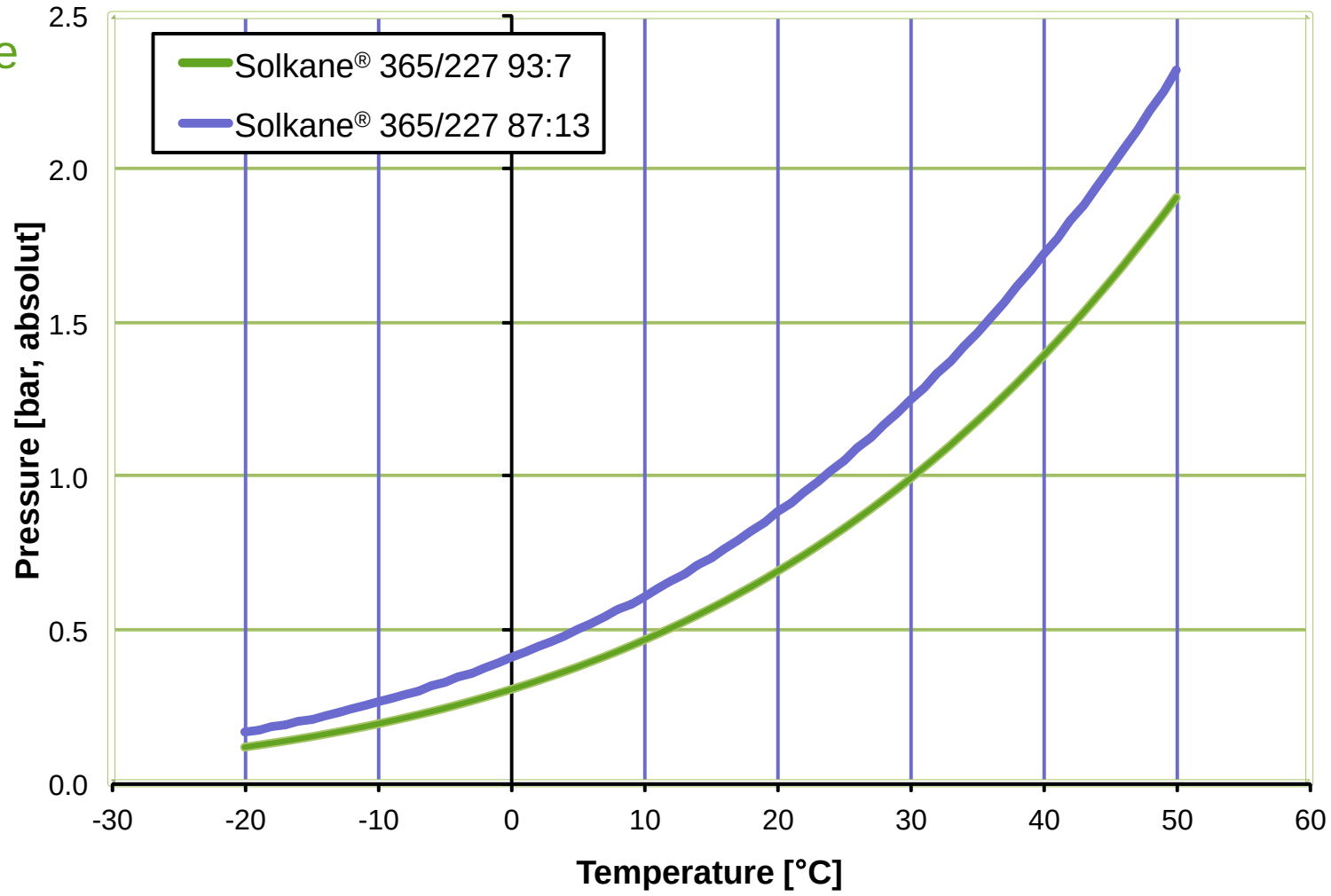
Comparative Physical properties
Eco-toxicology

	HCFC-141b	HFC-365mfc	HFC-365/227 93:7	HFC-365/227 87:13	HFC-245fa	c-Pentane	
Boiling Point	31.7	40.2	30	24	15.3	49.5	[°C]
Mol.-Weight	116.9	148.1	149.5	150.9	134	70	
Atm. Lifetime	9.3	8.6	8.6*	8.6*	7.6	“few days”	[years, IPCC 4, 2007]
ODP	0.11	0	0	0	0	0	
GWP	725	794	964	1109	1030	11	[IPCC 4, 2007]
VOC	no	no	no	no	no	yes	

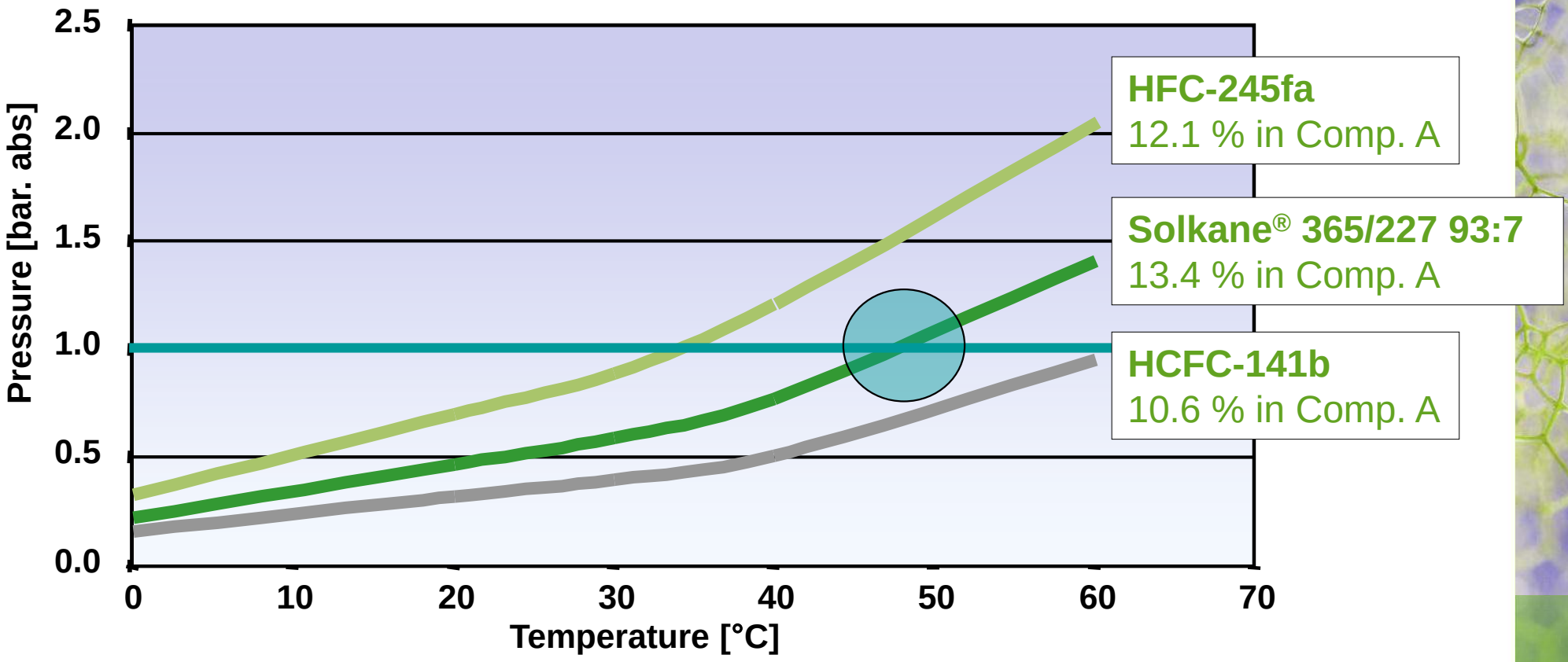
* based on pure Solkane 365mfc

Vapour pressure of Blends

Vapour pressure vs Temperature



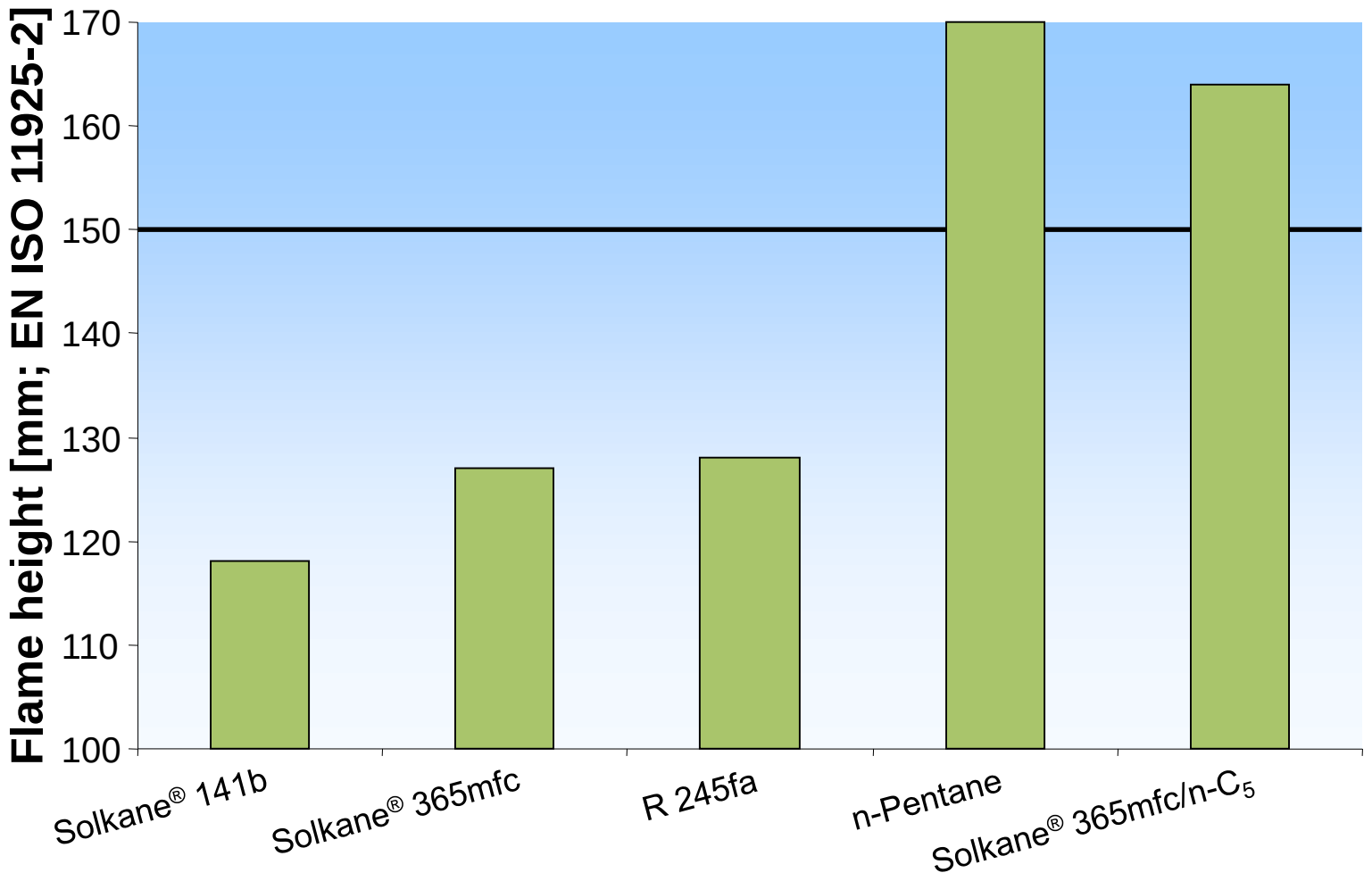
Vapour Pressure of Pre-Formulated PU Systems



Favorable handling – also in hot Climates!

Comparative Flammability in Foams

EN ISO 11925-2 – Ignitability Test (B2)

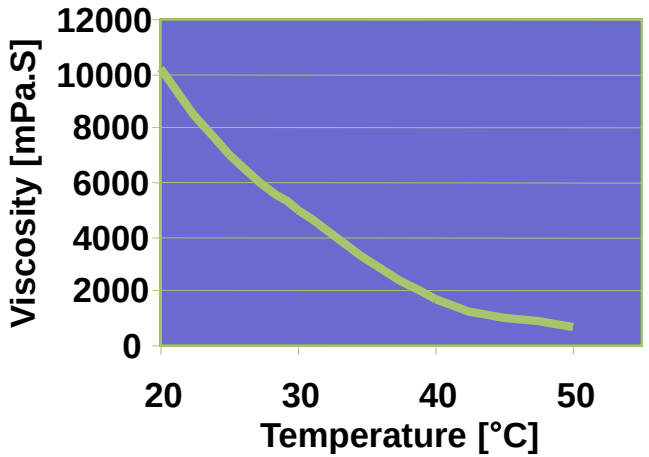


Characteristics of IXOL®

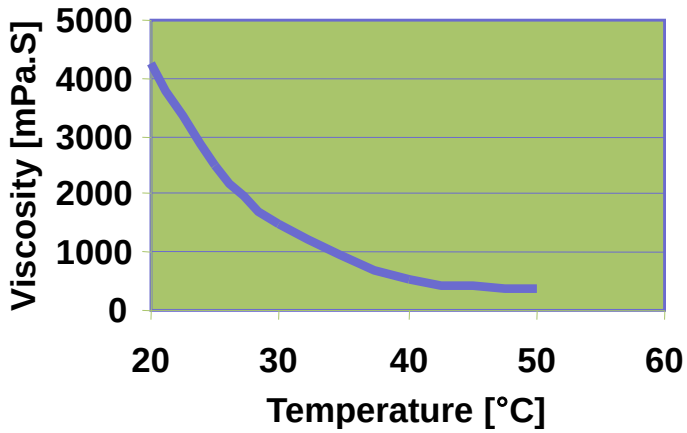
Property	Unit	IXOL® B251	IXOL® M125
Appearance		dark-brown liquid	dark-brown liquid
Density	[kg/dm³, 25 °C]	1.58	1.57
Viscosity	[mPa.s, 25 °C]	7000	2900
OH-Number	[mg KOH/g]	330	240
Functionality		3	2
Bromine content	[mass-%]	31.5	32
Chlorine content	[mass-%]	6.9	7
Water content	[mass-%]	< 0.2	< 0.2

Viscosity of IXOL

IXOL® B251



IXOL® M125

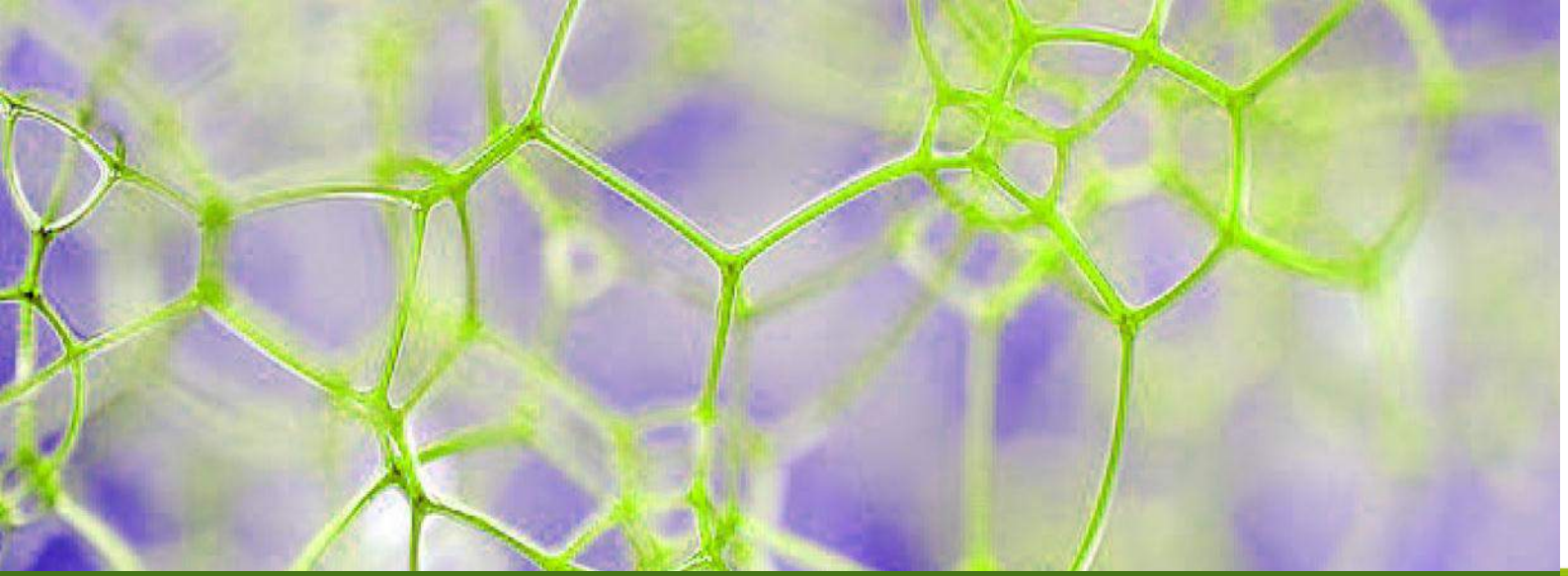


Performance of IXOL

Possibility to Produce PU Rigid Foams Which Achieve the Requirements of European and American tests

Example of Fire Tests

Single Burning Item	**EN 13823**	**Class C, S2**
USA	**ASTM E-84**	**Class 1**
Switzerland	**EMPA**	**Class V**
Older Tests:		
(France	**Epiradiateur NF P 92-501**	**Class M1)**
(Germany	**DIN 4102**	**Class B2)**
(United Kingdom	**BS 476, part 7**	**Class 1)**



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SOLKANE® 365 blends
IXOL® Products
Application

SOLKANE®

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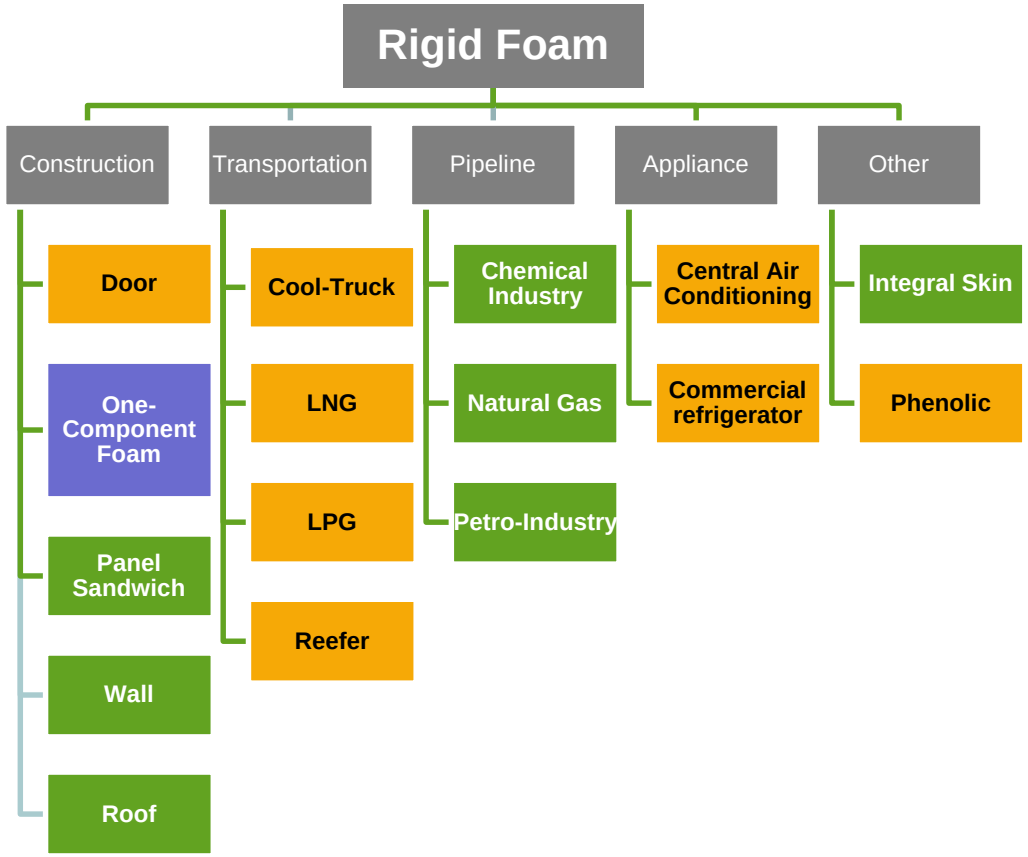
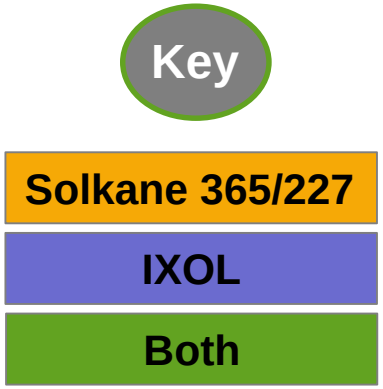
Typical Applications for Insulation Products
Blowing Agents



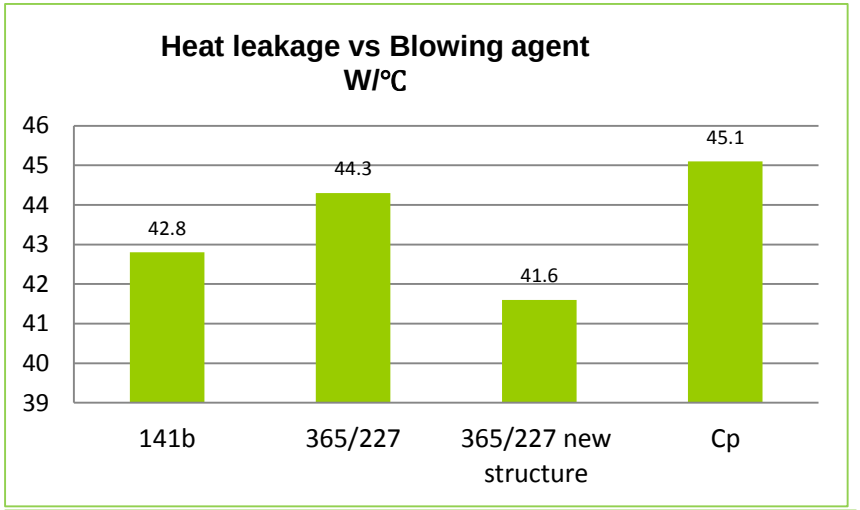


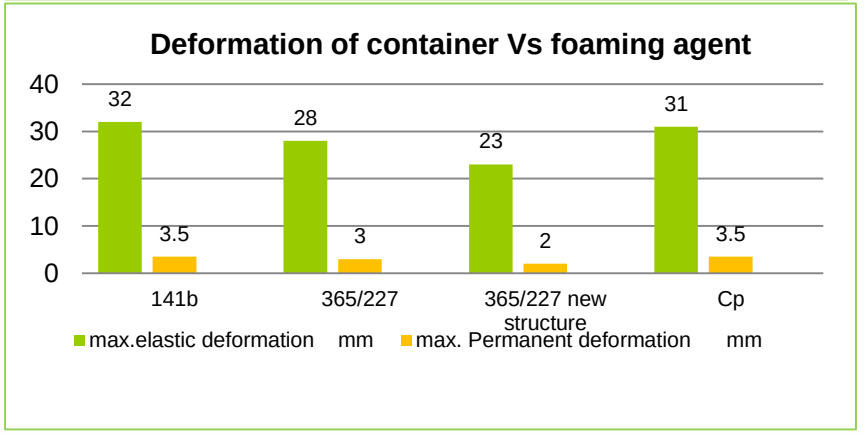
Application—Spray foam

- Benefits
  - Closest match to HCFC-141b of available replacements
  - Existing equipment can be used
  - Processing for end users match HCFC-141b
  - handling easy on site

Application—Reefer container & Refrigerated truck

- Benefits
  - improving heat leakage
  - better aging insulation performance for energy saving for long term
  - higher mechanical strength





Application---LNG

- Benefits
  - very similar mechanical strength to 141b
  - better insulation performance than H2O
  - lower density
  - good dimensional & compressive stability @ a large temperature range(-162℃~+30)℃

		Solkane ®365/227				HCFC 141b			H2O
		A	E	I	RPUF	A	E	I	RPUF
Fresh λ mW/m.K		21.0	22.5	24.4	26.1	20.8	22.2	23.8	37.4
Density Kg/m3		41.5	82.7	110.0	125.4	42.0	84.0	118.0	123.5
Compress strength Mpa	@ normal temp.	0.34	0.84	1.33	1.26	0.27	0.77	1.28	1.31
	@cryogenic temp	0.84	1.13	1.95	1.43	0.53	1.69	2.52	1.45

Application---Appliance

- Benefits
  - improving insulation performance
  - electricity saving every day
  - potential density reduction for cost saving

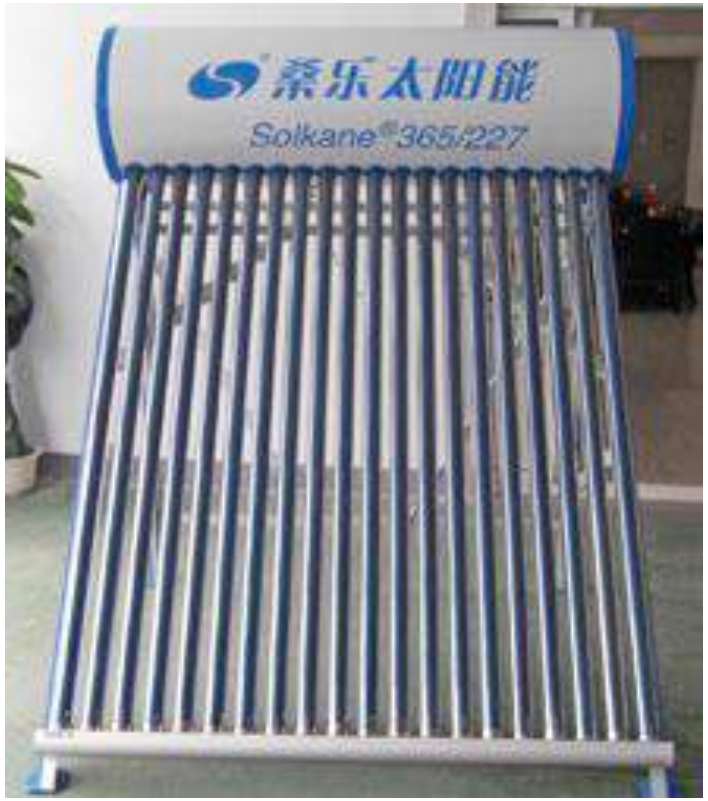
foam properties / Blowing system	Foam density（kg/m3）	Thermal conductivity（mW/m·K）	Compression strength（kpa）	Dimensional stability（%）
Cp	34	20.2	140	0.3
365/Cp co-blowing	30	17.8	160	0.1

Refrigerator type / Blowing agent	Normal	Energy saving	Three door
Cp	0.41 kwh/24h	0.398 kwh/24h	0.665 kwh/24h
365/Cp co-blowing	0.37 kwh/24h	0.356 kwh/24h	0.60 kwh/24h

Application---Solar impuls

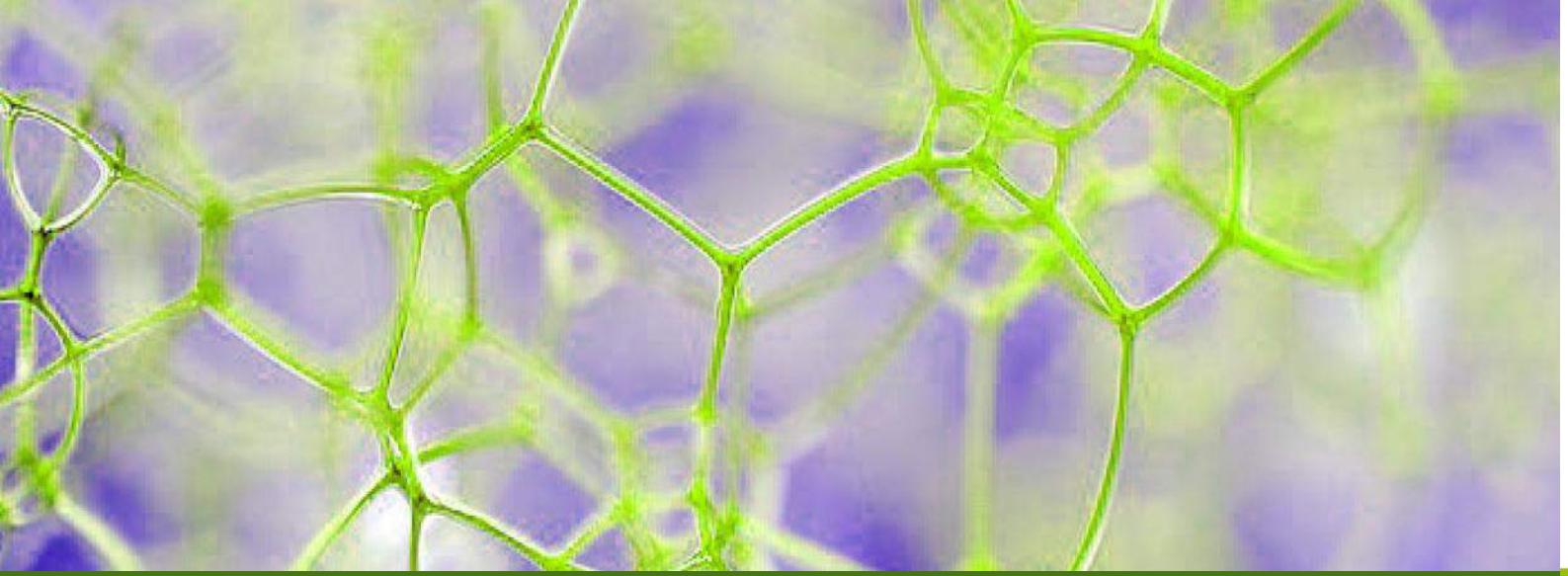
- Benefits
  - maximum insulation
  - with maximum strength
  - at lowest possible weight
  - excellent dimensional stability @ a large temperature range (-40°C~+100°C)

Application---Solar water heater



- Benefits
  - good insulation
  - higher mechanical strength
  - excellent dimensional stability @ a large temperature range (-40℃~100℃)

	HCFC141b	Solkane 365/227	Cp
Density kg/m3	55	47	52
λ@23℃ mW/m.K	19.1	20.5	22.8
Compress strength KPa	168	171	161



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Packaging & Delivery

SOLKANE®

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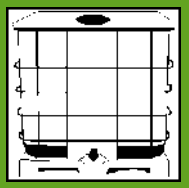
Product Delivery

				
SOLKANE® 365mfc	Content: 240kg Tara: 25.5kg FCL: 80 Drums	-	Content : 24m³	Content : 20m³ Tara: 3.6 – 4.5t
SOLKANE® 365/227	Content: 240kg Tara: 25.5kg FCL: 80 Drums	-	Content : 24m³	Content : 23m³ Tara: 3.6 – 4.5t
IXOL® B251	Content: 300kg Tara: 28.5kg FCL: 80 Drums	Content: 1500kg Tara: 60kg FCL: 13 IBC	Content : 24m³	-
IXOL® M125	Content: 300kg Tara: 28.5kg FCL: 80 Drums	Content: 1500kg Tara: 60kg FCL: 13 IBC	Content : 24m³	-

SOLKANE® 365/227

- Classification -

ADR 2013	HFC-365mfc	HFC-227ea	SOLKANE® 365/227 93:7	SOLKANE® 365/227 87:13
1.2.1 Definition	liquid	gas	liquid	liquid
2.2.2 Class 2	n.a.	non flammable	n.a.	n.a.
2.2.3 Class 3	flammable	n.a.	n.l. / n.f.	n.l. / n.f.
DOT				
§173.115	n.a.	non flammable	n.a.	n.a.
§173.120	flammable	n.a.	n.l. / n.f.	n.l. / n.f.
GHS				
1.2 Definition	liquid	gas	liquid	liquid
2.2.2 Gas	n.a.	non flammable	n.a.	n.a.
2.6.1 Liquid	Cat.2	n.a.	n.l. / n.f.	n.l. / n.f.

n.a. = not applicable
n.l. / n.f. = not listed / non flammable

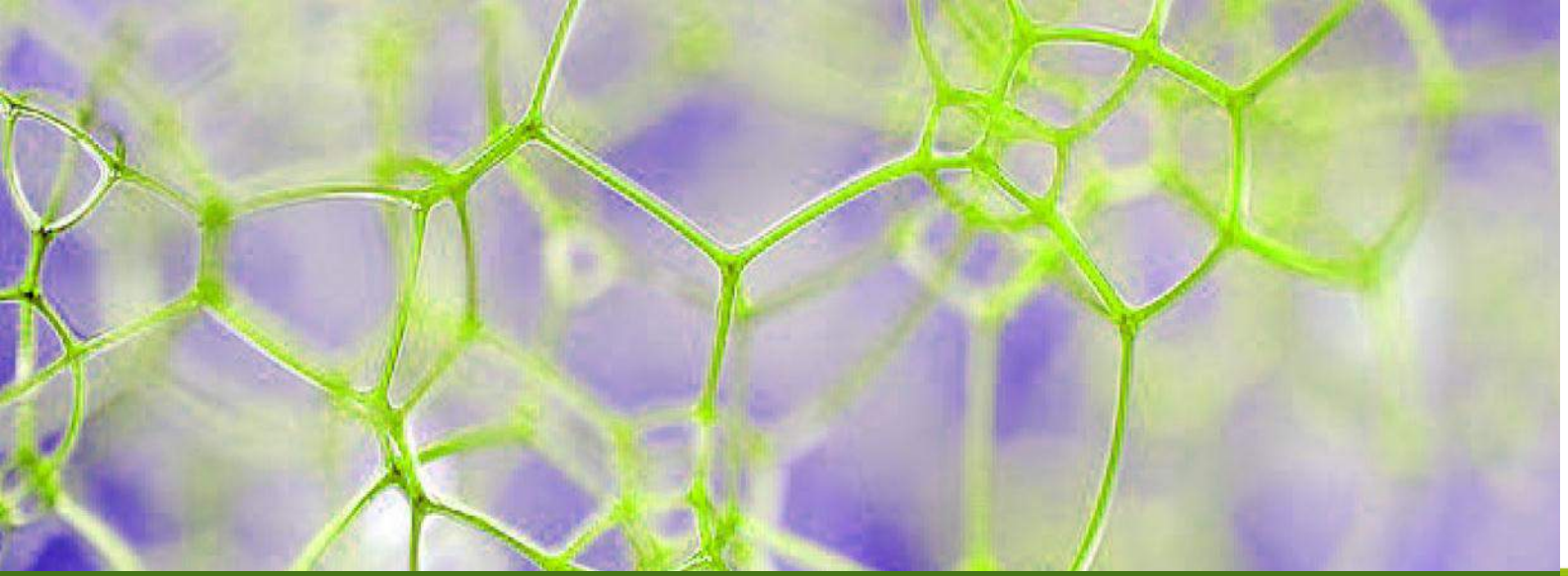
Solvay Product Delivery

SOLKANE® 365 blends:

- Emission-Free Bulk supply
- Dry Coupling System

"Closed Hose" system – product (gas phase) remains in the hose at all times.

- Avoids release of SOLKANE® 365/227
- Gas Displacement Procedure
- Slight constant nitrogen overpressure to operate day tank
- IXOL® Products:
- Global Markets in drums and totes
- Inside Europe, product available in drums, totes and tank cars



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Bulk Packaging

Guidance

SOLKANE®

01/10/2018

Bulk Storage

- Secure containers properly to prevent them from tipping, falling or rolling.
- Locate container in cool, dry, well ventilated area.
- Prevent inadvertent container movements and accidental damage (e.g. collisions with fork trucks).
- Follow all DOT and company transportation procedures.
- Avoid exposing containers to heat sources and any open flames.
- Avoid moisture and dirt from entering the container couplings and connections.

SOLKANE® 365/227
Preparation for Bulk unloading

- Storage vessel must be designed for SOLKANE® 365 and Blends of SOLKANE® 365/227 (Pressure and Materials)
- Storage vessel must be clean and free from any contaminants prior to storing SOLKANE® 365.
- Use control valves in storage system to avoid any accidental and unintended release of SOLKANE® 365
- Make sure all hose connections are in good condition, and are fixed at the storage tank.
- Pay attention to couplings and connectors: DN 50 ARTA dry coupling (female connection)
- Make sure that electrical grounding, overfilling alarm systems are working, and that you have electric power supply 32A for the pump
- Take care that the SOLKANE® 365 bulk delivery is connected with the right line of your filling system.

Bulk Unloading

Carrier Responsibilities (Road Tanker Delivery)

- Carrier connects the pump discharge to the vessel inlet using appropriate hoses and couplings.
- Carrier connects the storage tank unloading line and takes care that this is done without emissions and product contamination.

Storage Tank Operator Responsibilities

- The Storage Tank Operator is responsible for the storage and integrity of piping / hose connections, especially the permanent piping and coupling connections.
- The Tank Operator must insure all delivered product is connected to the right storage vessel or unloading line, respectively.
- Tank Operators are also responsible for operating valves, taking process readings and performing other miscellaneous operation duties.

Safety

- Carrier and Storage Tank Operator are required to follow all local plant safety and health procedures and regulations (e.g. PPE)

Tank Instructions (First Filling)

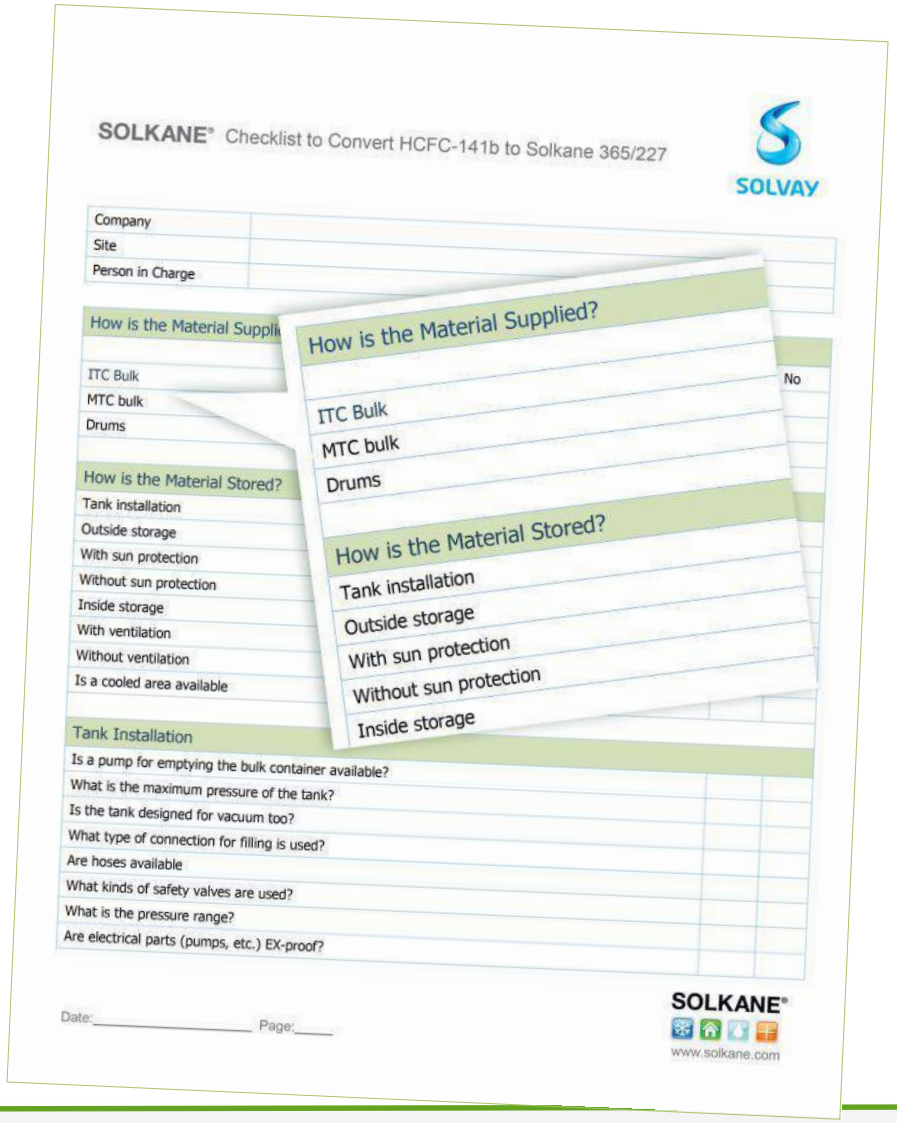
1. Check the vacuum on the storage tank
2. Check that the ITC valves and the tank valves are closed. Remove blind caps from the self-sealing couplings.
3. Connect the self-sealing couplings hose side with the self-sealing coupling ITC side.
4. Close the bypass valve between fluid and gas phase.
5. Open bottom valve of the ITC as shown in operating instruction
6. Slowly open ITC valve fluid
7. Open the ITC valve fluid completely
8. Open the storage tank valve fluid slowly
9. Check storage tank valve fluid are open and sight glass is flooded
10. Wait until the vacuum in the storage tank is broken
11. Switch on the pump
12. When the pressure in the storage tank is the same as in the ITC, open the gas phase
13. Watch storage tank level indicator 1 to make sure that no overfill has taken place (see red mark or hear alarm) Watch sight glass for completion of the filling operation and ensure that pump gets no dry running
14. Bubbles in the sight glass (container empty) Switch off pump.
15. Close the ITC valves and the storage tank valves.
16. Open the bypass valve between fluid and gas phase.
17. Disconnect the self-sealing couplings hose side with the self-sealing couplings ITC side
18. Install the blind caps from the self-sealing couplings
19. Store the self-sealing couplings orderly

Tank Instructions (Filling)

1. Check that the ITC valves and the storage tank valves are closed. Remove blind caps from the self-sealing couplings.
2. Connect the self-sealing couplings hose side with the self-sealing coupling ITC side
3. Close the bypass valve between fluid and gas phase.
4. Open bottom valve of the ITC as shown in operating instruction
5. Slowly open ITC valves
6. Open the ITC valves completely
7. Open the storage tank valve slowly
8. Check storage tank valves are open and sight glass is flooded
9. Switch on pump
10. Watch storage tank level indicator 1 to make sure that no overfill has taken place (see red mark or hear alarm) Watch sight glass for completion of the filling operation and ensure that pump gets no dry running.
11. Bubbles in the sight glass (container empty) Switch off pump.
12. Close the ITC valves and the storage tank valves
13. Open the bypass valve between fluid and gas phase.
14. Disconnect the self-sealing couplings hose side with the self-sealing couplings ITC side
15. Install the blind caps from the self-sealing couplings.
16. Store the self-sealing couplings orderly

SOLKANE® 365/227

Checklist



Bulk Unloading

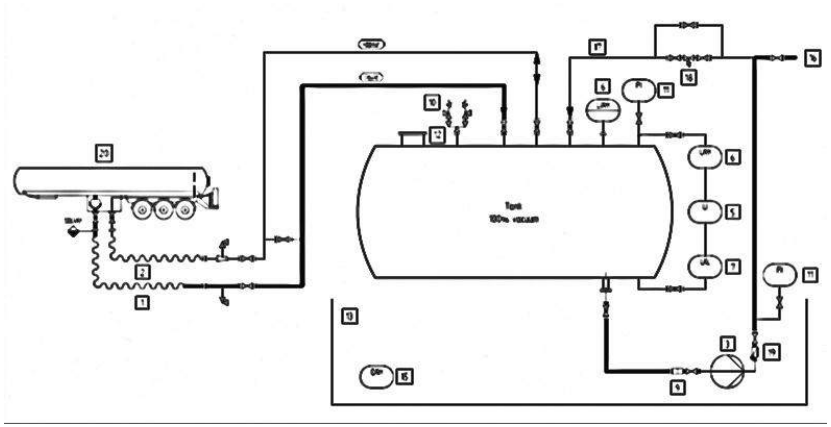
Connections / Couplings

SOLKANE® 365 and blends:
ITC
Dry Disconnect Coupling
liquid phase: DN50
gas phase: DN40

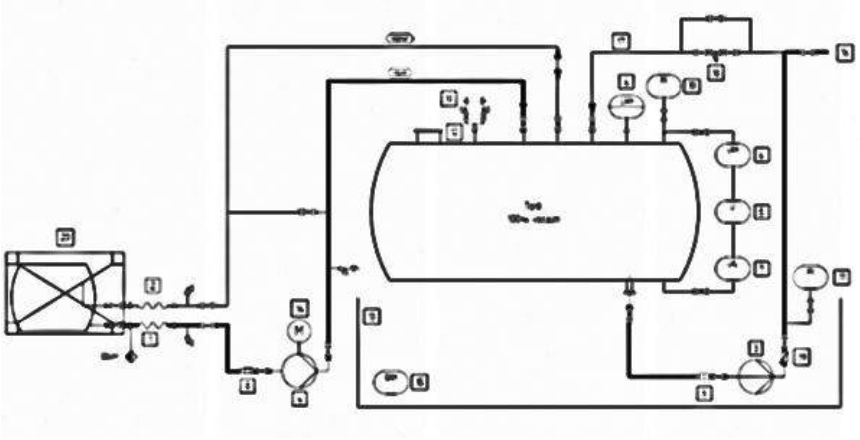
ARTA System
Dry Disconnect Coupling

SOLKANE® 365
Road Tanker
Dry Disconnect Coupling
liquid phase: DN50
gas phase: DN40

Examples of Bulk Unloading

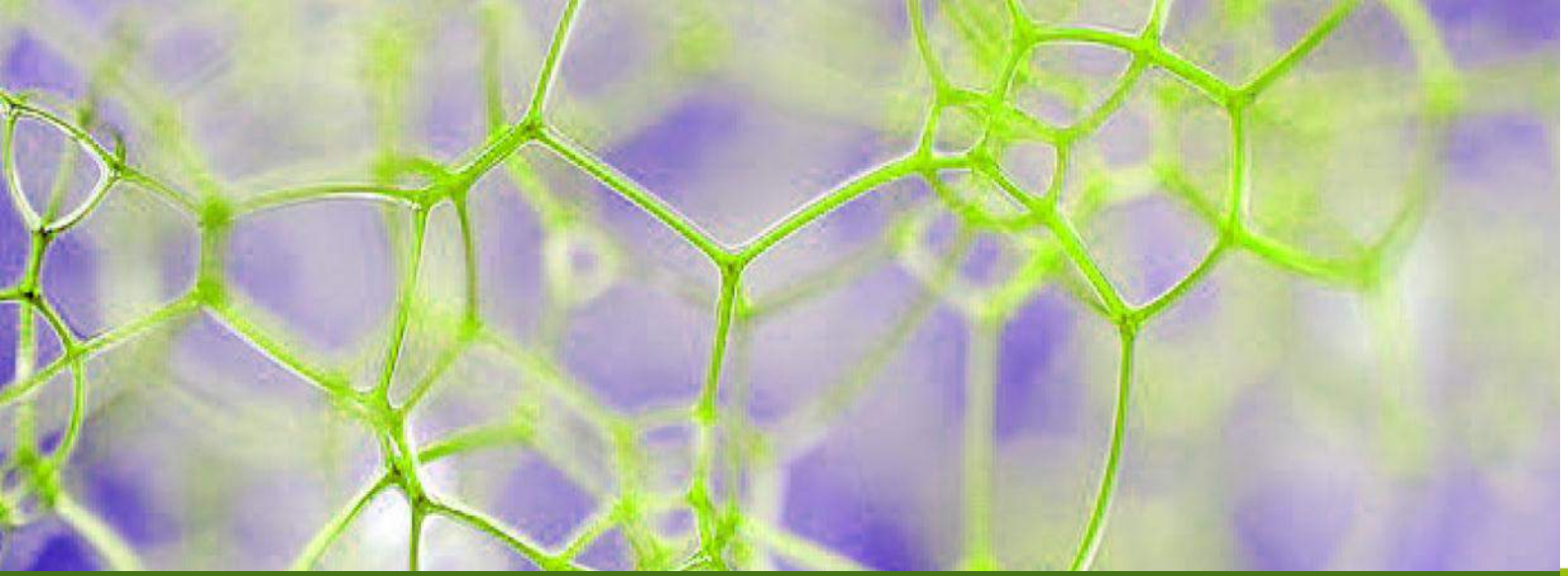


Storage and unloading of SOLKANE® 365/227 by road tanker



Storage and unloading of SOLKANE® 365/227 by ITC

For further Information about unloading procedures and possible system setups, please consult our Transport – Packaging - Storage brochure.



SOLVAY

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Drum Packaging

Guidance

SOLKANE®

01/10/2018

Drum Storage

- Secure drums properly to prevent them from tipping, falling or rolling.
- Locate drums in cool, dry, well ventilated area
- Prevent them from becoming falling objects and being damaged (e.g. collisions with fork lifters)
- Follow drum storage and local handling procedures (Occupational Safety & Health) for your site.
- Avoid exposing drums to heat sources and open flames.
- Keep the drum connections free of moisture and dirt.

SOLKANE® 365/227

Drum Storage

Storage

- Drums should remain tightly closed
- Store in non-hazardous area
- Exhaust system to remove SOLKANE® 365/227 vapour:
  - at floor level
  - at tap hole
  - malfunction alarm

Emptying

- Workspace:

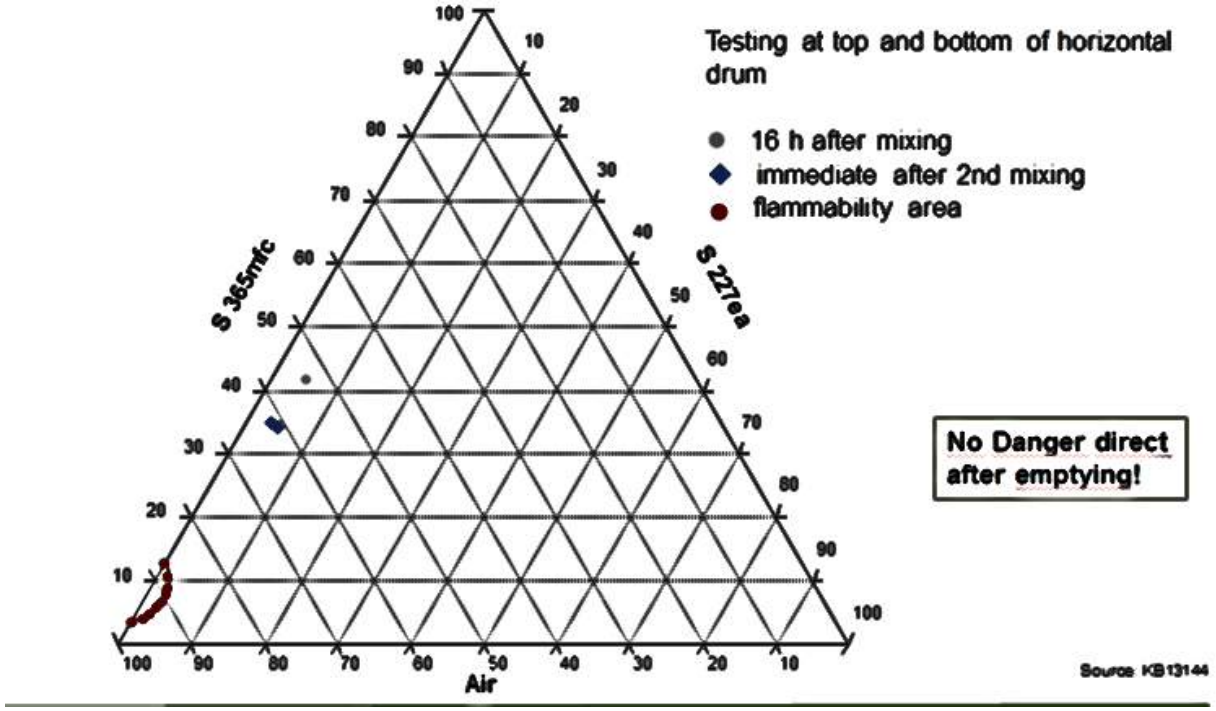
  Follow the national rules for safety e.g. 1999/92/EC ATEX
- Equipment:

  Follow the national rules under consideration e.g. of the Safety Data Sheet information
- After emptying:

  Concentration SOLKANE® 365/227 > UEL

SOLKANE® 365/227

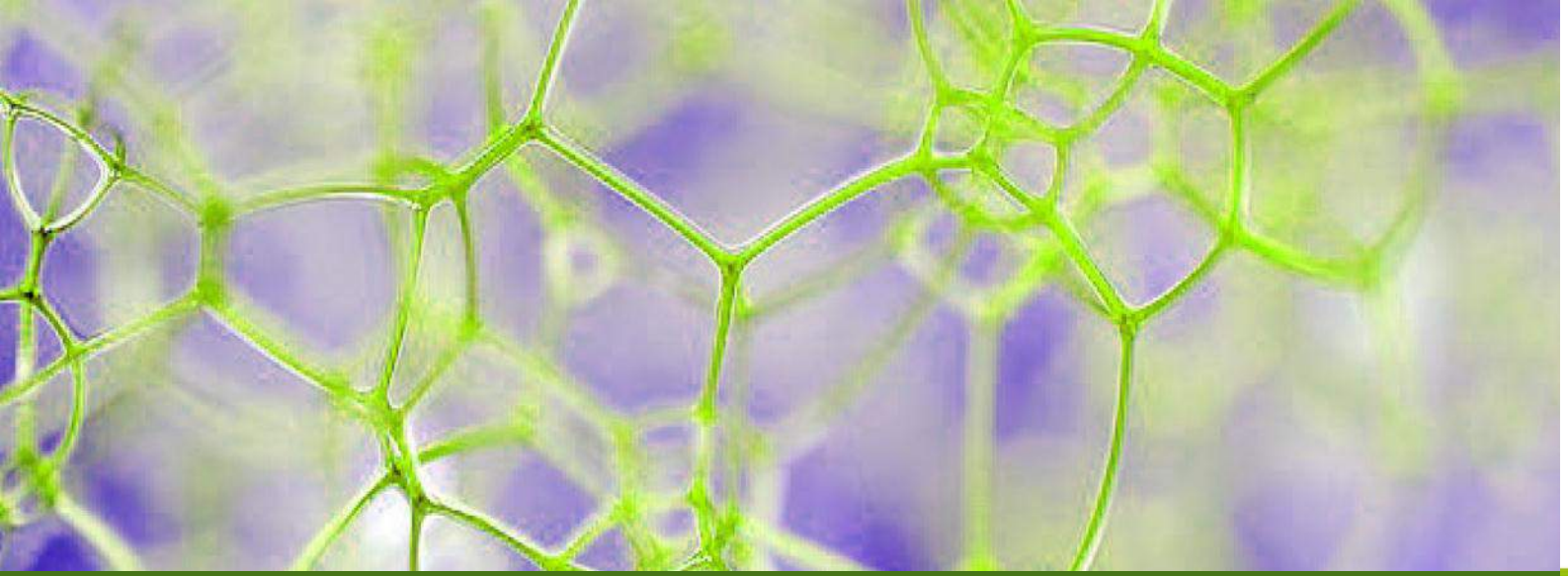
Is there a risk while emptying a drum?



Test Results:

- The flammability area is rather small and far away from conditions during emptying
- An open SOLKANE® 365/227 drum never creates a combustible atmosphere

SOLKANE® 365/227 is safe! Over 10 Years of operating experience without accident or incident.



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Key Takeaways

Blowing Agents and Flame Retardants

SOLKANE® 365 Foam Blowing Agents
Best Choice!

Easy & Safe to Handle

- SOLKANE® 365/227 Blends are non-flammable liquids
- Packaged in standard drums (no need for pressurized gas containers)

Best Performance in Use

- Best fire test results
- Best insulation value
- Easy conversion of HCFC-141b systems

Economic Advantage

- Less foam needed to achieve the same stability vs HCFC-141b
- Blends perfectly with all blowing agents

IXOL® B251 & M125
High Performance Flame Retardants

- Higher Bromine content that leads to better fire resistance.
- Reactive FR gives a permanent flame retardant effect.
- Moderate viscosity and a good compatibility with polyols.
- No affect on thermal insulation characteristics and mechanical properties.
- Polyester Triol gives more production stability of foaming.

www.solkane.com