

Aug 2017

SOLSTICE® LIQUID BLOWING AGENT (LBA)

Honeywell

Agenda

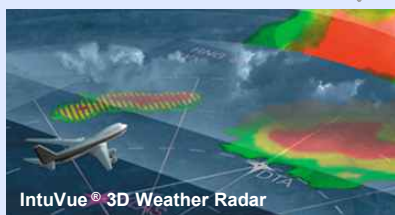
- **Honeywell Overview**
- **Solstice® Liquid Blowing Agent (LBA) Introduction**
- **Commercial Adoptions**
- **Awards and Recognition**

Honeywell Overview

NYSE: HON | ~1,300 sites | ~131,000 employees | Morris Plains, N.J. headquarters | Fortune 100

Aerospace

\$14.8B
Sales



Unmatched Scope of Offerings

- Mechanical, Cockpit, and Software Offerings From Nose to Tail
- Apps, Services, Maintenance, Subscriptions
- End-to-End Connectivity Solutions From Hardware to Airtime
- Turbochargers for Fuel Efficiency

Home and Building Technologies

\$10.7B
Sales



Connecting Homes and Buildings

- Security and Fire
- Connecting Homes With Lyric™
- Open Software Connecting "Internet Of Things" in Buildings

Performance Materials and Technologies

\$9.3B
Sales



Winning Technology

- Refining and Petrochemical Catalysts
- Gas Processing Modular Offerings
- Solstice® LGWP Materials
- SmartLine Transmitters
- Asset Optimization Software

Safety and Productivity Solutions

\$4.6B
Sales



Connecting Workers

- Wireless, Voice, Mobility, Data Analytic Solutions for Workers
- Warehouse Automation
- Keeping Workers Safe

Reflects 2016 Full Year Results









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Aligned to Key Global Macro Trends



Solstice[®] Liquid Blowing Agent (LBA) Introduction

Fluorine Products Generations of New Products

1 st Gen	2 nd Gen	3 rd Gen	4 th Gen
CFC Chlorofluorocarbons <i>Genetron® 11</i> <i>Genetron® 12</i>	HCFC Hydrochlorofluorocarbons <i>Genetron® 141b</i> <i>Genetron® 22</i>	HFC Hydrofluorocarbons <i>Enovate® 245fa</i> <i>Genetron® 134a</i>	HFO Hydrofluoroolefins <i>Solstice® LBA</i> <i>Solstice® GBA</i>
Ozone Depleting 			
ODP 1.0	ODP 0.1	ODP 0	ODP 0
Global Warming 			
GWP < 5000	GWP < 1000	GWP < 1000	GWP ≤ 1
Honeywell Products	<i>Genetron</i>	<i>Genetron</i> <i>Enovate</i>	<i>Solstice</i>

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Honeywell Innovation = Environmental Breakthroughs

Comparison of Environmental Properties*

Property	HCFC-141b	Enovate® 245fa	HFC-365mfc HFC-227ea (93/7)	Cyclo- pentane	Methyl formate	Methylal	Solstice® LBA
Molecular structure	CCl_2FCH_3	$\text{CF}_3\text{CH}_2\text{CHF}_2$	$\text{CF}_3\text{CH}_2\text{CF}_2\text{-CH}_3$ $\text{CF}_3\text{-CHF-CF}_3$	$(\text{CH}_2)_5$	HCOOCH_3	$(\text{CH}_3\text{O})_2\text{CH}_2$	$\text{CF}_3\text{CH=CHCl}$
ODP	0.1 ¹	~0 ¹	~0 ¹	~0 ¹	~0 ¹	~0 ¹	~0 ³
GWP, 100 year	782 ²	858 ²	982 ²	<25 ¹	~1 ⁴	<25 ¹	1 ²
VOC Status (Fed US) ⁴	Exempt	Exempt	³ Exempt	VOC	Exempt	VOC	Exempt

* These are but some of a mosaic of properties that must be evaluated in assessing candidate blowing agents

1. 2010 Report of the Rigid and Flexible Foams Technical Options Committee (FTOC) 2010 Assessment, Appendix 1; http://ozone.unep.org/Assessment_Panels/TEAP/Reports/FTOC/
2. IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
3. No impact on ozone layer depletion and is commonly referred to as zero. Ref: Preliminary report: Analyses of tCFP's potential impact on atmospheric ozone; Dong Wang, Seth Olsen and Donald Wuebbles, Dept. of Atmospheric Sciences, University of Illinois, Urbana, IL
4. Manufacturer Literature

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Honeywell Provides Best Environmental Solutions

Comparison of Flammability*

Property ¹	HCFC-141b	Enovate [®] 245fa	HFC-365mfc ² HFC-227ea (93/7)	Cyclopentane	Methyl formate	Methylal	Solstice [®] LBA
Molecular structure	CCl ₂ FCH ₃	CF ₃ CH ₂ CHF ₂	CF ₃ CH ₂ CF ₂ -CH ₃ CF ₃ -CHF-CF ₃	(CH ₂) ₅	HCOOCH ₃	(CH ₃ O) ₂ CH ₂	CF ₃ CH=CHCl
Flashpoint (°C)	None	None	None	-37	-19	-30.5	None
Flame Limits, vol % (LEL-UEL)	7.6-17.7	None	None	1.1-8.7	4-23	2.2-19.9	None

1- Manufacturers' literature

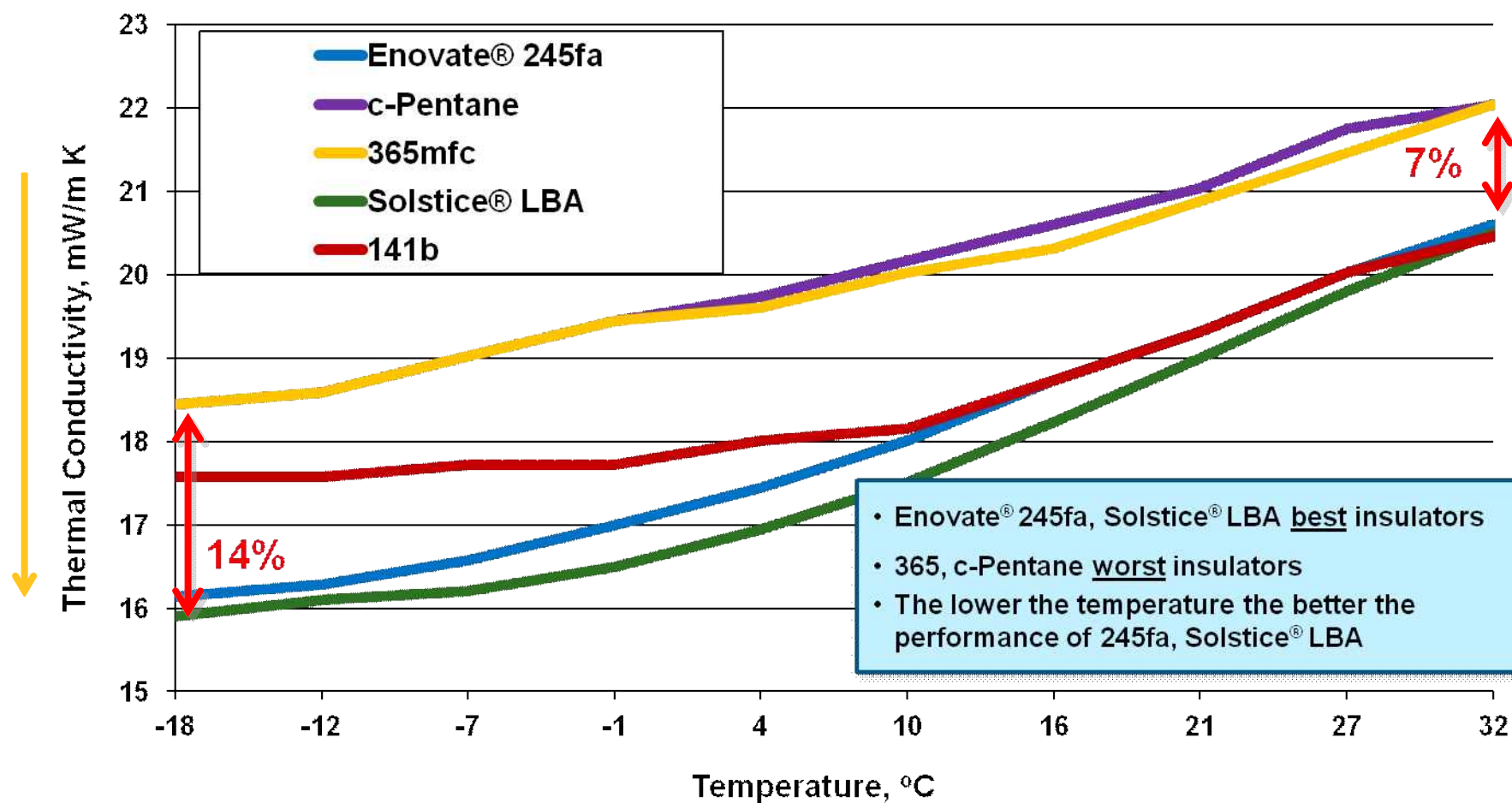
2- HFC-365mfc is flammable. The non-azeotropic blend is considered non-flammable if the concentration of HFC-227ea is > 5 %. Reference Solvay Technical literature Solkane-365-227-blends

* These are but some of a mosaic of properties that must be evaluated in assessing candidate blowing agents

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Honeywell Provides Non- Flammable Solutions

Insulation Performance Varies with Temperature

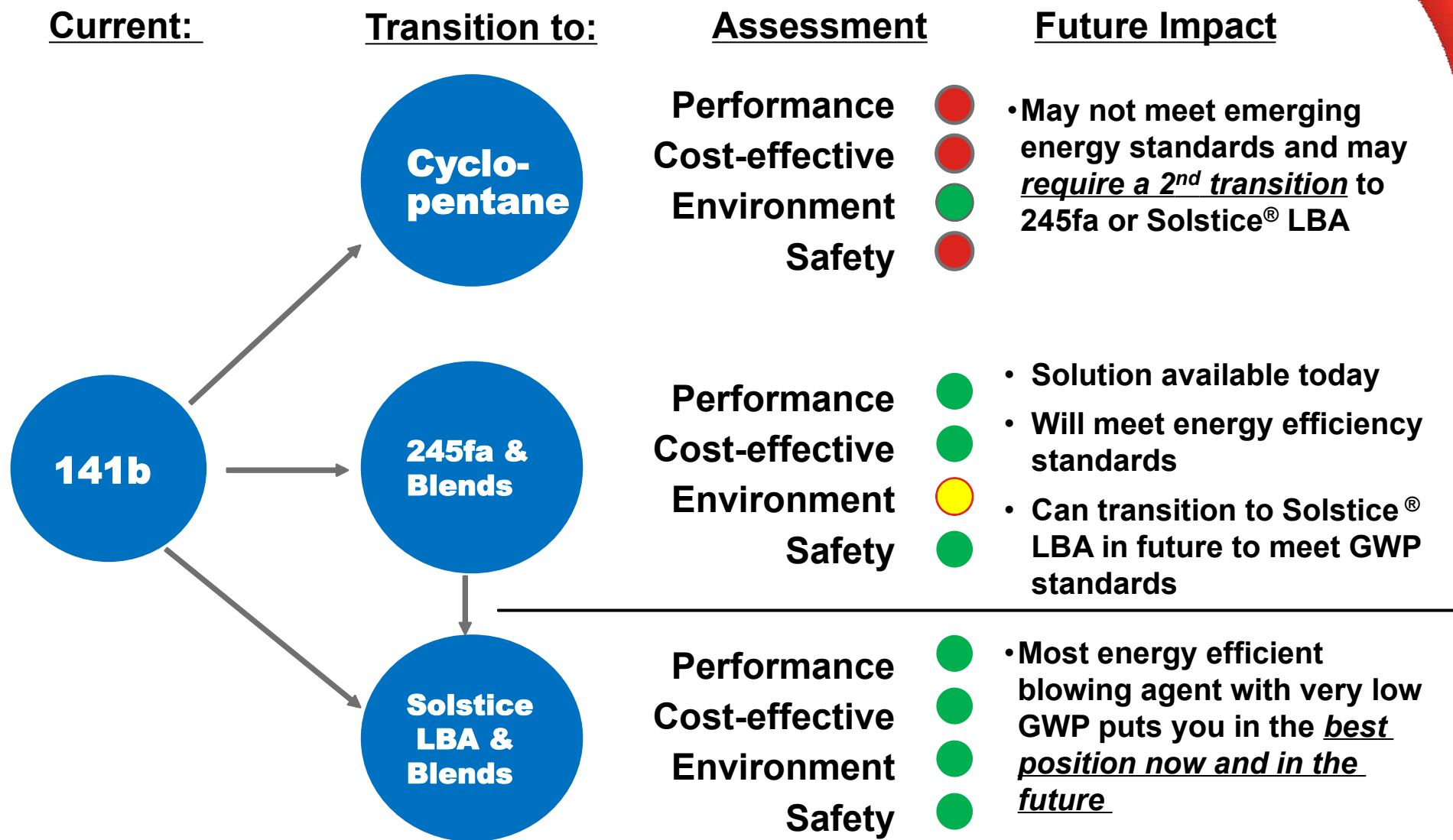


k-factors will vary by formulations

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Enovate 245fa and Solstice® LBA are superior to 365mfc and cyclopentane at all temperatures and this advantage is even greater at low temperatures.

Transitioning from HCFC 141b



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Solstice® LBA: Low Capital and Cost Transitions, Most Efficient and Environmentally Superior



Commercial Adoptions

Solstice® LBA applications

Appliances



Spray foam



Insulation panel



LNG ship



Reefer container

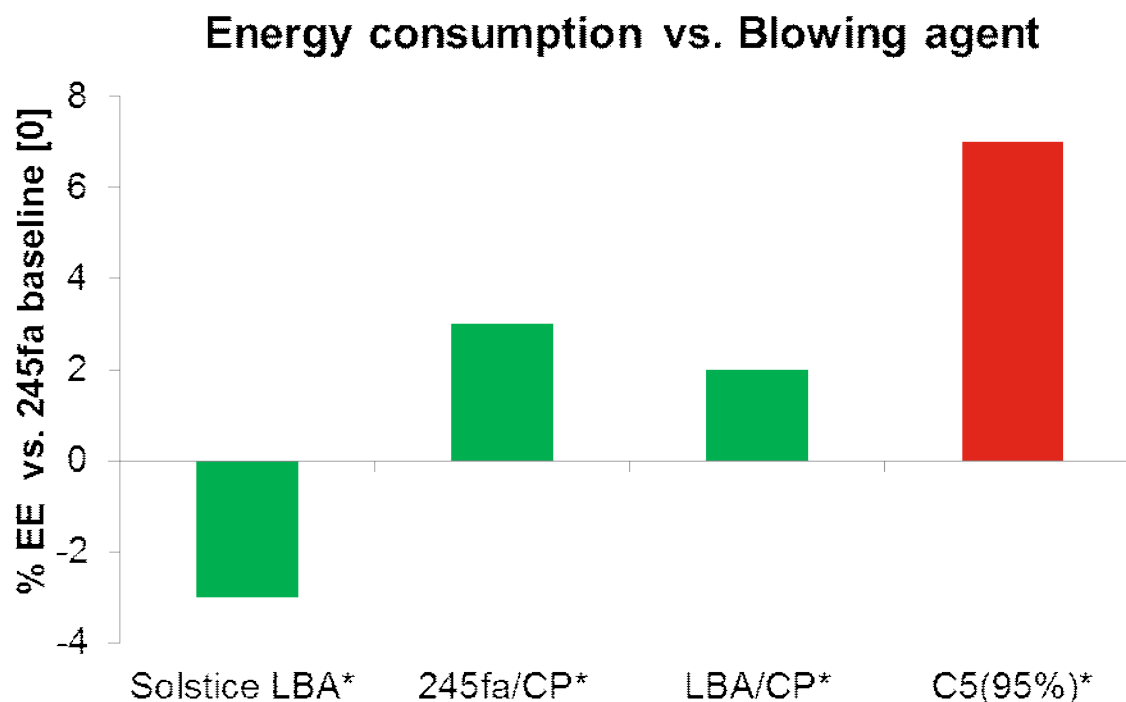


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Many applications for Solstice® LBA

Solstice[®] LBA - Appliance

- Best insulation performance of any blowing agent
- Ultra-low global warming potential
 - GWP=1, equiv to CO₂
- Non-ozone depleting
- VOC-Exempt (U.S. EPA)
- Non-flammable



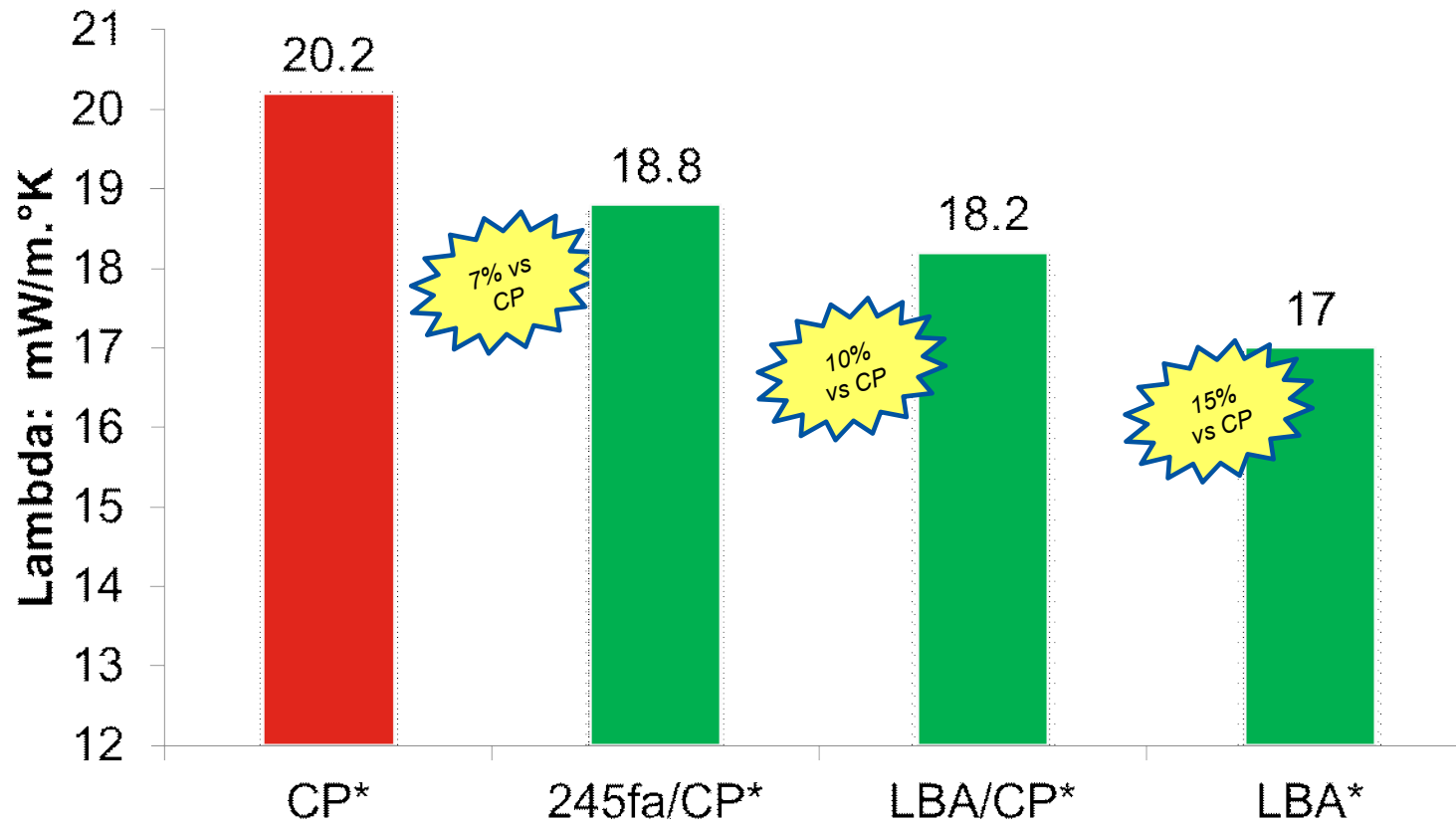
*Formulation tailored for the blowing agent

*Test result from Chinese OEMs

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Pure Solstice[®] LBA system: improve EE by 9% compared with CP system

K-factor of refrigerator foam for Chinese OEMs



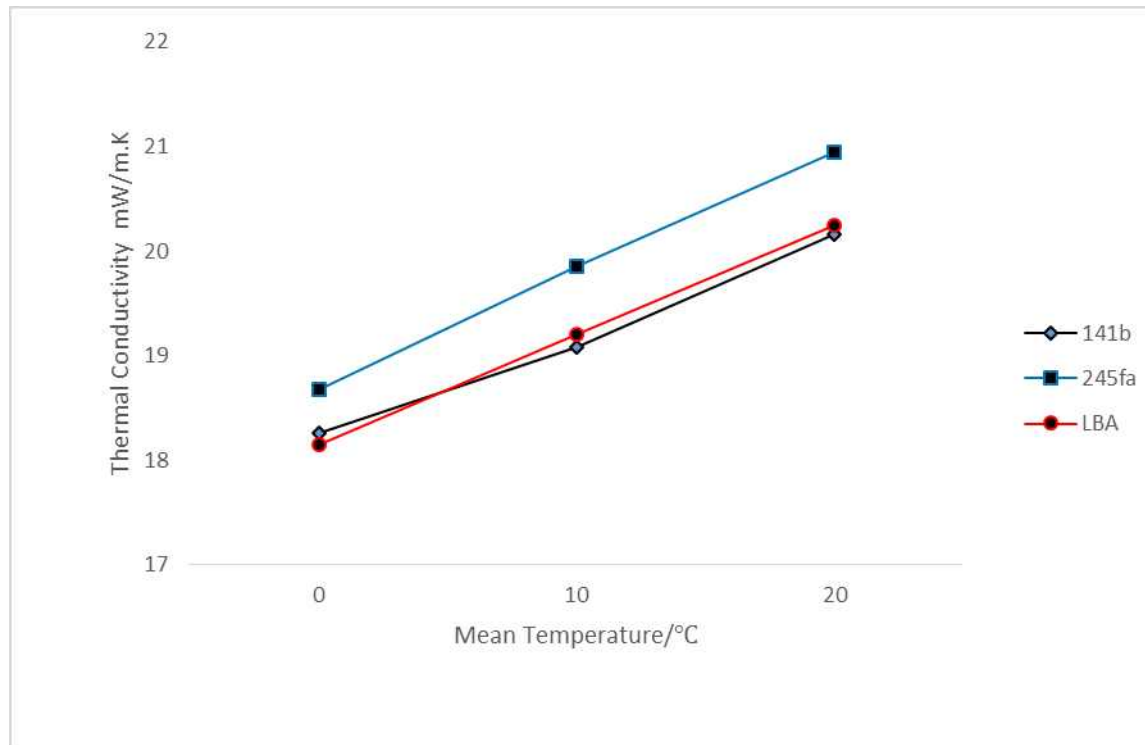
* Formulation tailored for the blowing agent

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Pure Solstice® LBA system : 15% improvement over cyclopentane baseline

Solstice[®] LBA - Spray

Initial Thermal Conductivity (Lambda)



- Solstice[®] LBA :

- 3~4% better insulation than 245fa
- Similar thermal conductivity as 141b system
- Small process parameter difference
- No new equipment requirements

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Solstice[®] LBA System Shows Better Insulation than 245fa System

Solstice® LBA “Takes Off” at the Cleveland Airport



BENEFITS RELATIVE TO ENOVATE® 245fa

- 2-4% higher insulation value
- 8-10% better yields (materials savings)
- Higher compressive strength
- Improved foam performance across a wide range of surface temperatures (extends the spray season)
- Lower clogging of guns (contractor benefit)



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Solstice® LBA Performance Benefits vs Enovate 245fa

Solstice[®] LBA: Spray Foam (UAE)



Ain Al Fayda, UAE (2015)



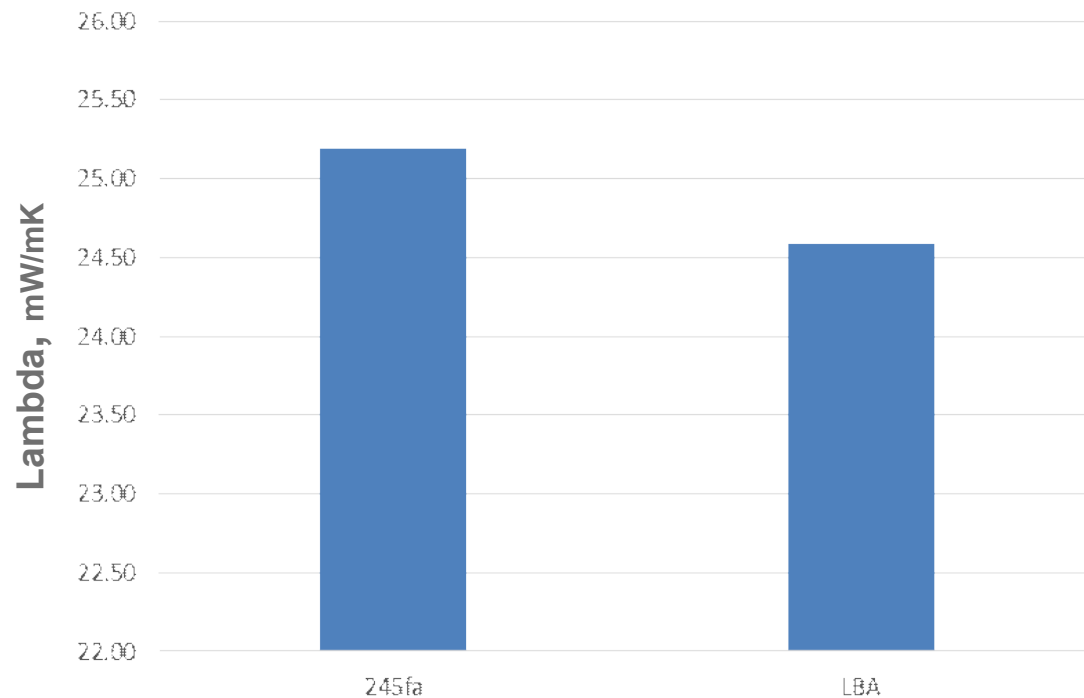
BENEFITS OF SOLSTICE LBA RELATIVE TO HCFC-141b

- Superior cold substrate application, quick rise similar to HCFC-141b
- Ease of application when the external ambient is less than 10°C
- 7-12% higher yields
- 30% higher compressive strength at lower loading of blowing agent
- Equivalent initial k-factor (0.1595 (BTU in/hr ft² °F) @ 24°C)
- Better substrate adhesion to metal surfaces
- Equivalent dimensional stability at lower loading at 75°C /90°C /-30°C

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Great Low GWP, High Energy Efficiency Solution

Solstice® LBA – LNG CARRIERS



Tested at mean temperature 20degc

- **Solstice® LBA**

- ~3% lower lambda than 245fa system at room temperature, and similar lambda as 245fa system at cryogenic temperature
- First LNG ship with Solstice LBA insulation delivered in 2016

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Solstice® LBA Provides Similar Boil-off Rate as HFC-245fa for the Membrane Type LNG Ships

Field trials with LBA – Continuous PIR board

Process Parameters

Temperatures

Polyol/Isocyanate <20°C (68°F)

Mixing head <25°C (77°F)

Laydown <23°C (73°F)

Pressure

Mixing head 130 bars (~1900psi)

Line speed > 10m/min (32ft/min)

Drop-in evaluation in a cyclopentane formulation

Properties	Measured
Density, kg/m ³	32.8
Initial Lambda at 10°C, mW.mK	17.1
R-value at 10°C	8.4
Compressive Strength, kPa	165
Closed Cell, %	92.9

Drop-in evaluation in an iso-pentane formulation

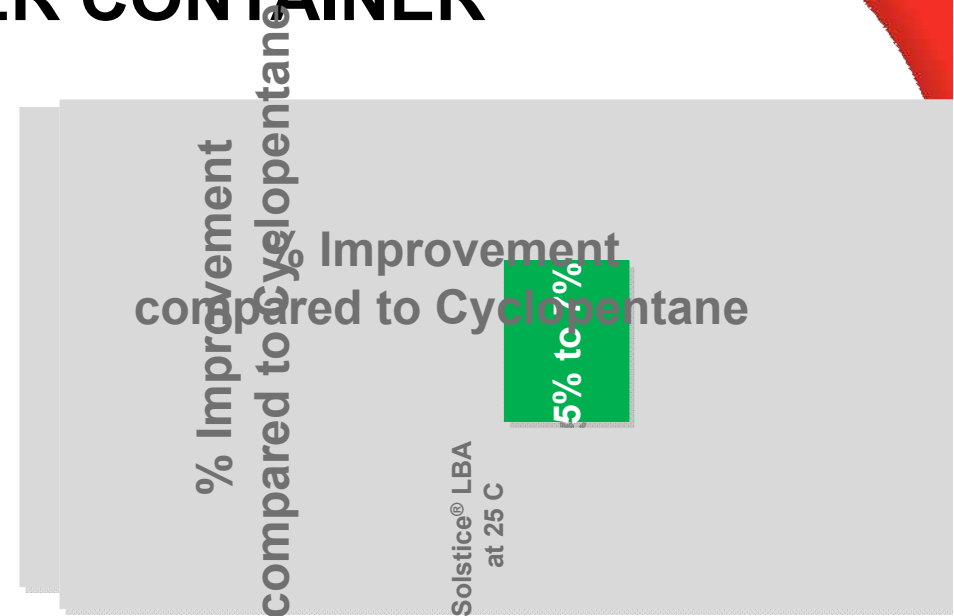
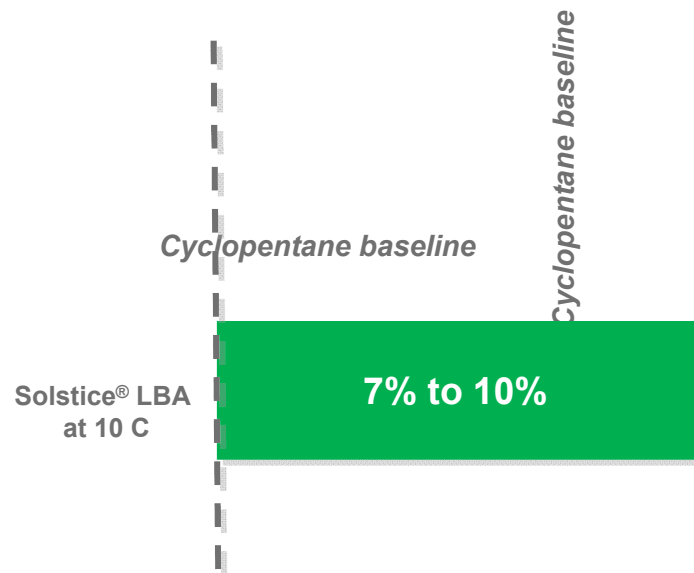
Properties	Measured
Density, kg/m ³	32.2
Initial Lambda at 10°C, mW/mK	17.1
R-value at 10°C	8.5
Compressive Strength, kPa	124
Closed Cell, %	97.6

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Solstice® LBA blown foam offers excellent insulation performance.

SOLSTICE® LBA – REEFER CONTAINER

Thermal Conductivity



Data generated during unoptimized commercial production runs

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Solstice® LBA maximizes energy efficiency and reduces operating cost



AWARDS AND RECOGNITION

Solstice® LBA and GBA Large Scale Plant



- First Solstice LBA plant in US, Q2, 2014
- First Solstice GBA plant in US, Q4, 2014
- Plan to set up second Solstice LBA plant in China, H2, 2018

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Large-scale Plant Operational in US Since 2014

Honeywell | Blowing Agents



- 1 **AFINOX**
- 2 **BASF**
Weiss Technik
- 3 **COVESTRO**
- 4 **Dow**
- 5 **FESTIVO**
- 6 Finland: Commercial Freezer OEM
- 7 **Fisher & Paykel**

- 8 **Haier**
- 9 **Hisense**
- 10 **HOSHIZAKI**
- 11 Japan: Commercial Appliance
- 12 Japan: Commercial Appliance OEM
- 13 **Midea**
- 14 **OSO**
HOTWATER

- 15 **Rheem**
- 16 US: Domestic Refrigerator
- 17 **Whirlpool**
- 18 **atlantic**
- 19 **ACCELLA**
PERFORMANCE MATERIALS
- 20 **BAYER**
Bayer Pearl
- 21 **DEMILEC**

- 22 **ELASTOCHEM**
Specialty Chemicals Inc.
- 23 **ICP**
- 24 **Henry**
- 25 **LAPOLLA**
- 26 **NCFI**
POLYURETHANES
- 27 **Puitem**
- 28 **SOS**
Polyurethane Systems

- 29 **Synthesia**
- 30 **TOYO TIRES**
driven to perform
- 31 **TCI** **HUNTSMAN**
Polyurethanes
- 32 **AWIP** **ALL WEATHER INSULATED PANELS**
- 33 **CIMC**
- 34 **Kingspan**
- 35 **mcns**
Manufacturing Chemicals

- 36 **UNIT45**
- 37 **ABRISO**
- 38 **AUSTROTHERM**
Dimmoxolite
- 39 **fibraxps**
- 40 **JACKON**
INSULATION

Honeywell
THE POWER OF CONNECTED

Solstice® LBA Global Recognition by Industry and Government

Grand Prix



17th Ozone Layer
Protection and Global
Warming Prevention
Technology Grand
Prix

Innovation Award



Center for the
Polyurethanes
Industry
Innovation Award

Building Green Products Award



Top 10 Green
Product of 2016
by Building Green

Excellence Award



Governor's Iowa
Environmental
Excellence Award

Winning Awards Globally for Innovation and Sustainability

Whirlpool Media Day (Jan 22, 2014)



Whirlpool Corporation Partners with Honeywell, Announces Use of Next Generation Solstice® Liquid Blowing Agent in U.S. Refrigerators



Whirlpool Amana Goes Greener



New product promises to make Whirlpool greater

By Aly Brown



Whirlpool using new insulation at Amana refrigerator plant

New insulation will not increase the cost of a refrigerator or freezer, officials said

A new type of foam insulation in use at Whirlpool's Amana Division plant is producing refrigerators and freezers that are more energy efficient and will dramatically slash ozone-depleting greenhouse gases.

Honeywell Solstice Liquid Blowing Agent has a global warming potential that is 99.9 percent less than 245fa, the most commonly used foam blowing agent used within the appliance industry. Whirlpool is replacing 245fa with the Honeywell product, which produces a more uniform insulation within the doors and walls of a refrigerator.

The new insulation, which has been approved by the U.S. Environmental Protection Agency, has a global warming potential of 1 — the same as carbon dioxide.

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Whirlpool starts production at Amana...

Afinox Adopting Solstice® LBA in EU



“The use of Honeywell’s Solstice LBA in the foam is helping us improve the energy efficiency of our refrigerators, which is beneficial not only to customers and manufacturers, but to society as a whole.”

Civiero Karim,
R&D Manager, Afinox Srl.

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Solstice® LBA helps improve industry’s environmental footprint

Solstice® LBA Adopted by Top 3 Chinese OEMs

Honeywell

News Release

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MIDEA TO ADOPT HONEYWELL'S NEXT-GENERATION INSULATING MATERIALS IN ENERGY-EFFICIENT REFRIGERATORS

Low-Global-Warming Blowing Agent for Closed Cell Foam Insulation to Help Leading Chinese Appliance Manufacturer Meet Current and Future Energy and Environmental Regulations

MORRISTOWNSHIP, N.J., Nov. 6, 2013 -- Honeywell (NYSE: HON) announced today that Midea, a leading Chinese appliance manufacturer, will adopt Honeywell's next-generation Solstice Liquid Blowing Agent (LBA) to insulate Midea refrigerators and freezers.

◀ Midea: November 2013

▼ Haier: September 2014

Honeywell

News Release

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WORLD'S LARGEST APPLIANCE MANUFACTURER TO USE HONEYWELL'S LOW-GLOBAL-WARMING-POTENTIAL INSULATING MATERIAL IN ENERGY-EFFICIENT REFRIGERATORS

China-based Haier will use Solstice® Liquid Blowing Agent in large-capacity refrigerators

MORRIS TOWNSHIP, N.J., Sept. 18, 2014 – Honeywell (NYSE: HON) announced today that the world's largest appliance manufacturer, will adopt Honeywell's new low-global-warming-

Honeywell

News Release

Media Contacts:

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LEADING CHINESE APPLIANCE MANUFACTURER ADOPTS HONEYWELL LOW-GLOBAL-WARMING-POTENTIAL INSULATION MATERIAL

Hisense will use Honeywell's Solstice® blowing agent for refrigerator and freezer insulation in China

SHANGHAI, April 7, 2015 – Honeywell (NYSE: HON) announced today that Hisense, a leading Chinese appliance manufacturer, will begin using Honeywell's low-global-warming-potential (GWP) insulation

◀ Hisense: April 2015

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Top 3 Chinese OEMs Using Solstice LBA

US Spray Foam Adopts Solstice® LBA

LAPOLLA'S CUTTING EDGE SPRAY FOAM – SOLSTICE LBA

Benefits to Solstice compared to HFC 245fa

- Highest insulation value
- Global Warming Potential (GWP) of 1
- Lower vapor pressure improves storage and handling
- Improved foam performance across a wide range of surface temperatures
- Less clogging of spray guns

LEARN MORE



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LaPolla launched spray foam in April 2015... others following

Momentum building in Japan

(3) 2013年(平成25年)12月15日(日曜日) (第13版)朝日新聞

フォー ム タイ

この人に聞く

注目のHF
我々
とて14年は重

次世代の環境対策として、建築分野で注目を集めている「ハーフセル」の活用が、建築界で注目を集めている。ハーフセルは、従来の発泡スチロールよりも、断熱性能が約2倍、強度が約1.5倍、そして、燃焼時に発生する熱が約1/10と、環境に優しい材料として、建築界で注目を集めている。ハーフセルは、従来の発泡スチロールよりも、断熱性能が約2倍、強度が約1.5倍、そして、燃焼時に発生する熱が約1/10と、環境に優しい材料として、建築界で注目を集めている。

サンジー・ラストギ氏

Cool Performance

NEWS RELEASE

2013年12月1日
株式会社 日本アーク

『アクアフォームNEO(材)』新発売
新発泡ガス(HFO)で業界初の木造(軸組)防火試験合格～国交省へ認定申請～
12月1日から寒冷地をはじめ日本全国で発売、施工開始

株式会社日本アーク(本社: 神奈川県横浜市、社長: 中村文雄)は、建築用断熱用吹付け建築用レタフォームの環境対応型製品として、新発泡ガス(HFO)を用いた『アクアフォームNEO(材)』を12月1日から北海道をはじめ日本全国で発売、施工開始いたします。

断熱性・作業性に優れた建築用レタフォームの吹付け工法で、多くの建築会社にて採用されている日本アークには、ノンフロン製品だけでなく、より高い断熱性能と環境負荷軽減の両立が可能な吹付け建築用レタフォームの需要が多く寄せられておりました。これらのご要望にお応えするために、このほど新発泡ガスとしてHFO(ドフロム)を採用し、代替フロン(HFC)製品と同等の断熱性能が得られる吹付け建築用レタフォームを開発し日本全国で施工する体制を整えました。

従来の、建築用断熱用吹付け建築用レタフォームは、代替フロン(HFC)タイプとノンフロン(水素系)タイプの2種類が使用されておりましたが、それぞれにメリット、デメリットがありました。

今回の新製品『アクアフォームNEO(材)』は、代替フロン(HFC)タイプ、ノンフロンタイプの両方の長所を兼ねており、表裏共に採用したHFOは、オゾン層破壊係数(GWP)が「0」(ゼロ)、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献いたします。また、従来のHFCと同等の断熱性能が得られるため、現在のノンフロンタイプで採用されていたアークの厚さを薄くすることができます。

日本アークでは今後が期待される『アクアフォームNEO(材)』の長所を生かし、断熱性能の要求が一層高くなっていくことを、日本全国で供給、施工できる体制を整えましたが、施工対象も建築物(ビル・マンション)だけでなく、木造住宅にも採用できるようにいたしました。とくに木造住宅に採用する際の防火認定に関しては、すでに評価機関で評価(木造軸組)の防火性能試験に合格しており、国土交通省に申請し防火認定書を取得する運びとなっています。

このように、日本アークでは「人と環境にやさしい断熱」がより一層普及することを目標としております。

『アクアフォームNEO(材)』の概要は、以下の通りです。

新製品の断熱性能	
熱伝達率 (W/m²・K)	0.026 以下
厚さ (mm)	100 以上
燃焼性 (JIS A)	100 以上
燃焼性 (JIS B)	100 以上

●環境対応
環境対応型HFOを採用することでオゾン層を保護すると地球温暖化の防止に貢献します。

① HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

② HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

③ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

④ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

⑤ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

⑥ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

⑦ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

⑧ HFO(ドフロム)はオゾン層破壊係数(GWP)が「0」(ゼロ)と、地球温暖化係数(GWP)も「0」(ゼロ)と、地球温暖化防止に貢献します。

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Honeywell

News Release

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**LEADING JAPANESE COMPANY TO USE HONEYWELL'S
LOW-GLOBAL-WARMING-POTENTIAL BLOWING AGENT
FOR SPRAY FOAM INSULATION**

Honeywell Solstice® Liquid Blowing Agent will help Achilles Corp. meet current and future energy and environmental regulations

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Japan adoption increasing rapidly... several announcements

Reefer Industry Is Adopting Solstice®

2014 Europe Intermodal
Exhibition

Special Reefer produced for
Europe owner



Property
Summary
(Solstice
vs. Cp)

Property	Stakeholder Benefit
Superior Insulation	Lower operating costs / more energy efficient
Greater strength	Support reefer durability and enhances lifetime duration
Better flow and fill	Reduces scrap and rework
More even density distribution	Consistent energy efficiency

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Launched at Europe Intermodal 2014

Kingspan Adopting Solstice® in EU

Insulation

Kooltherm® K14 Insulated Plasterboard

INSULATED PLASTERBOARD FOR MECHANICALLY FIXED DRY-LINING



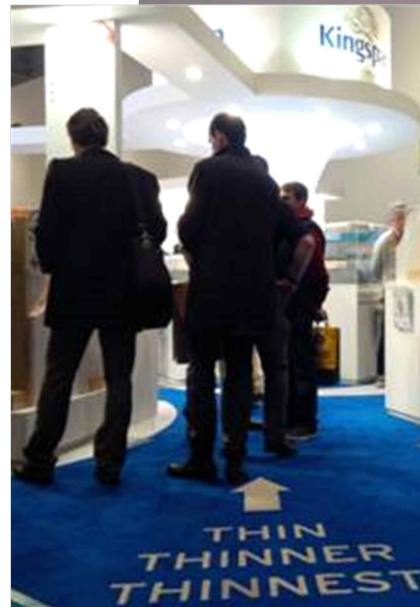
- Premium performance rigid thermoset insulation – thermal conductivities as low as 0.019 W/m.K
- Class 0 fire rating
- Insulation, dry-lining and vapour control in one board
- 9.5 mm plasterboard
- Allows quick response heating
- Unaffected by air infiltration
- Resistant to the passage of water vapour
- Easy to handle and install
- Ideal for new build and refurbishment
- Manufactured with a blowing agent that has zero ODP and low GWP

Even Thinner Even Better

Kingspan
Low Energy – Low Carbon Buildings

Kooltherm® K13 & K14 Insulated Plasterboard

- Premium performance insulation, vapour check and a plasterboard finish – combined in one board
- Thinner plasterboard – only 9.5 mm.
- Ultra-low thermal conductivity – as low as 0.019 W/m.K.
- Made using Honeywell Solstice® LBA.
- Low Global Warming Potential (GWP) – even better.



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Launched at EcoBuild March 2014

Summary – Solstice[®] LBA

- **Global adoptions underway across multiple applications**
 - 18 Appliance Manufacturers currently utilizing Solstice LBA
 - 18 Spray, panel and reefer adoptions to date
- **Energy efficiency is the primary driver:**
 - Up to 10% better than cyclopentane in appliance
 - 6-8% better than 245fa in spray foam systems
- **HFCs coming under regulatory pressure in the US, EU and globally**
- **Solstice products are fully commercial, registered and sold / distributed globally**
 - First Solstice LBA and GBA plants are on line in US, 2014
 - Plan to set up the second Solstice LBA plant in China, H2, 2018

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Honeywell is Prepared for Evolving Regulations, Customers Adopting Now



<http://www.honeywell-blowingagents.com>

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