



## 2nd Regional Symposium

"Alternative Refrigerants for Air-Conditioning Industry in High-Ambient Temperature Countries; the Way Forward"

# Next generation refrigerants

## A Daikin perspective

17/10/2012

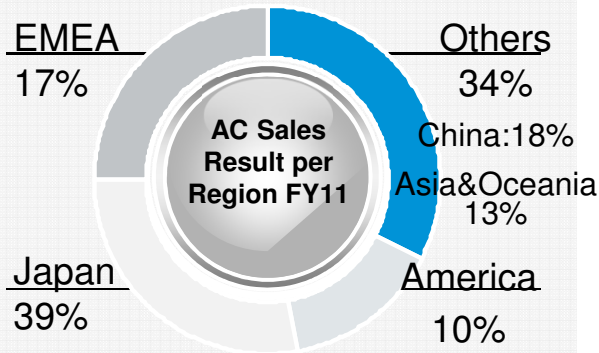
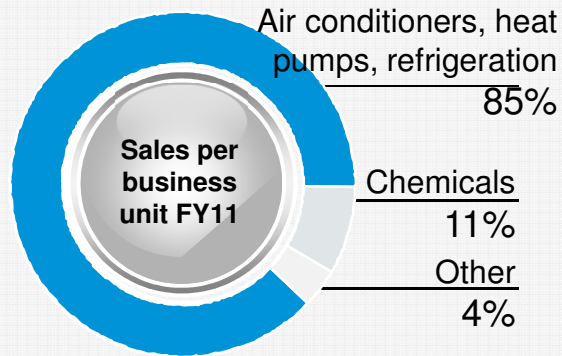
Martin Dieryckx, Daikin Europe N.V.

# DAIKIN worldwide



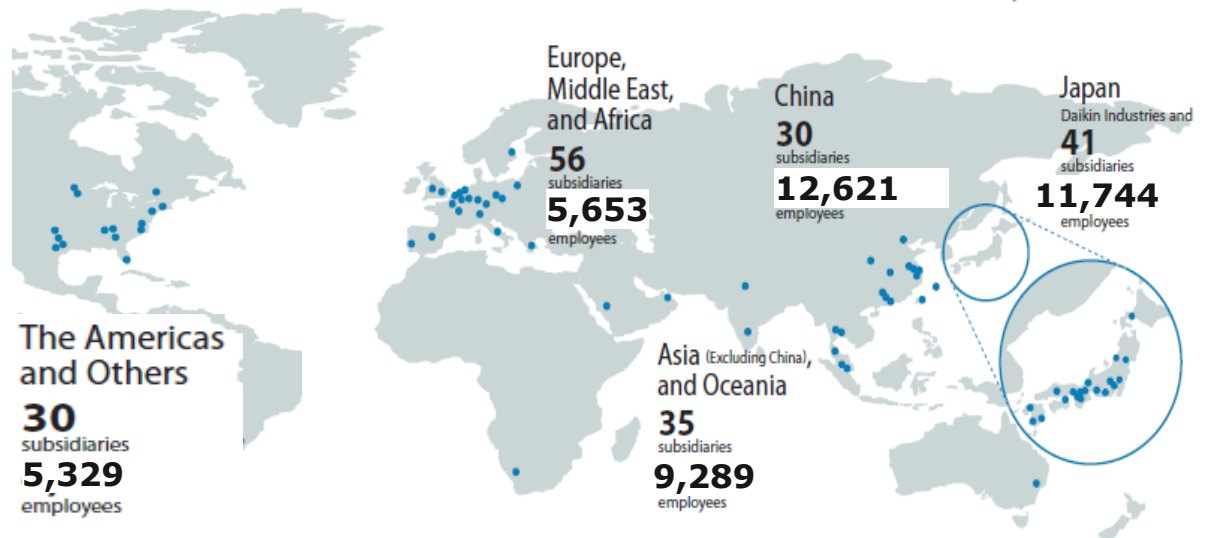
## Daikin Industries Ltd.

- Turnover: **11,181 Mio Euro**
- No. of employees: **44,636**  
(FY2011 Consolidated)



**As the only company in the world manufacturing both refrigerant and equipment, Daikin has a special responsibility to provide environmentally beneficial products that mitigate global warming**

## *Daikin Group Worldwide*



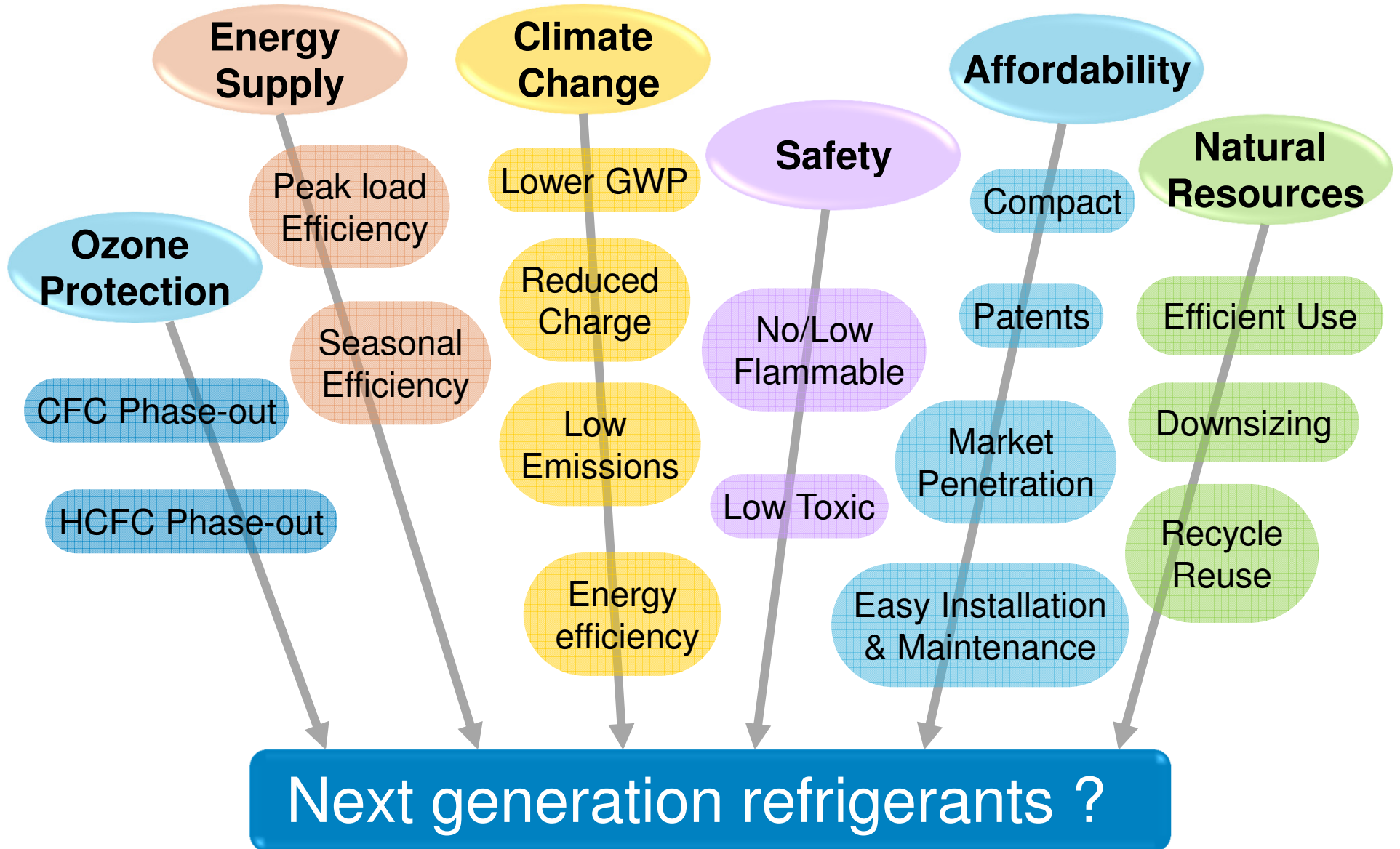
**Total manpower : 45000**



# Basic refrigerant policy

## -Diversity of Refrigerant Choice

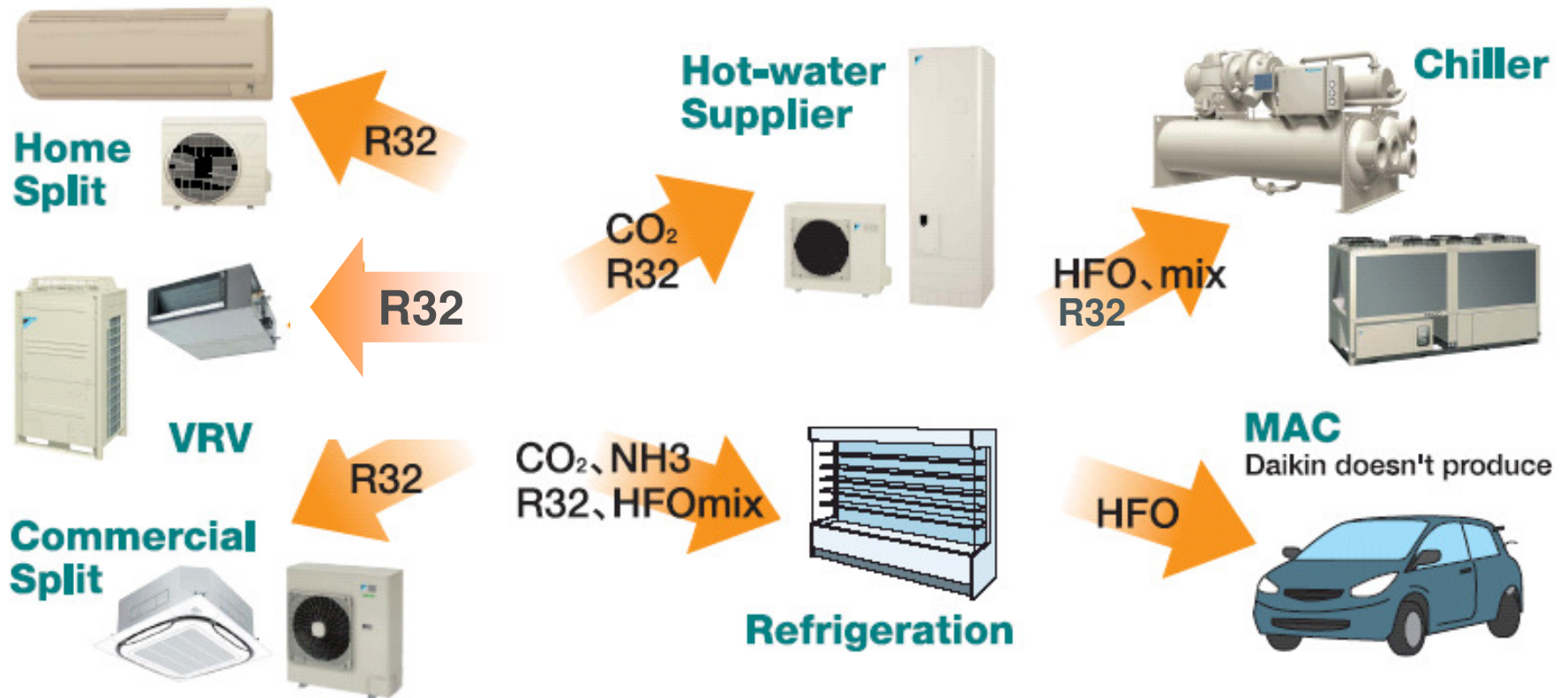
# Many factors to consider..



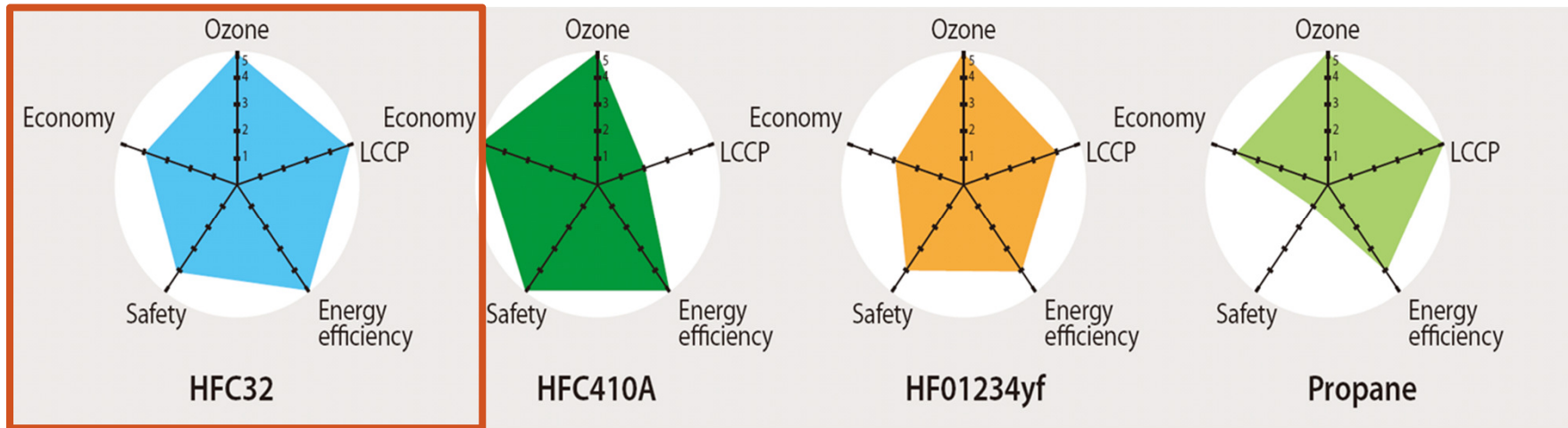
# Diversity of refrigerant choice



- There is no one-size-fits-all solution.
- All refrigerant are included on the table of refrigerant choice  
Choose whatever refrigerant is best suited for each application.
- Daikin is developing R32 split air –conditioners from residential to commercial range because R32 is better suited to these applications



# Why R32 for air conditioners & heat pumps?



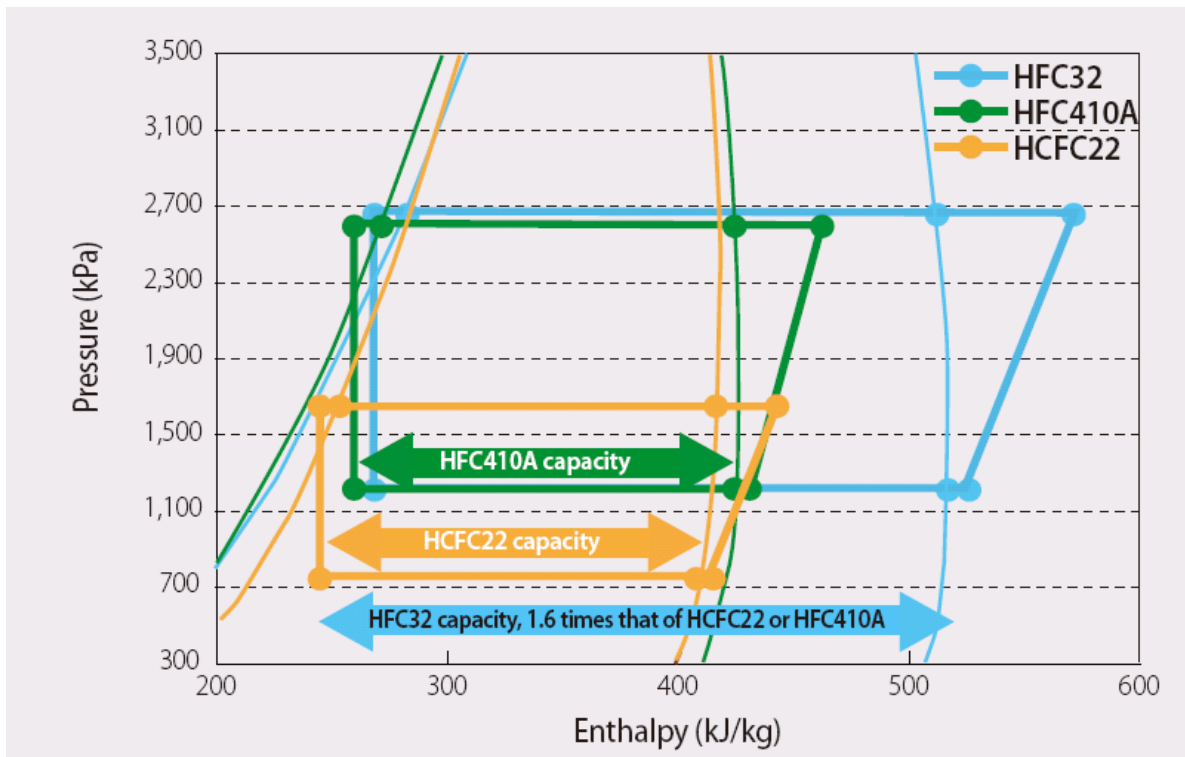
## R32 IS THE MOST BALANCED SOLUTION

- › Not depleting the ozone layer
- › Smaller Global Warming Impact (LCCP) compared to R410A & R22
- › Higher Energy Efficiency compared to R410A at high ambient conditions
- › Reduced refrigerant charge possible
- › More compact design possible
- › Acceptably safe because only slightly Flammable (Class A2L)
- › Refrigerant Production capacity is available (R32 is a component of R410A)
- › Easy to recycle and reuse (single component refrigerant)
- › Affordable for Article 5 countries

# Properties of R32



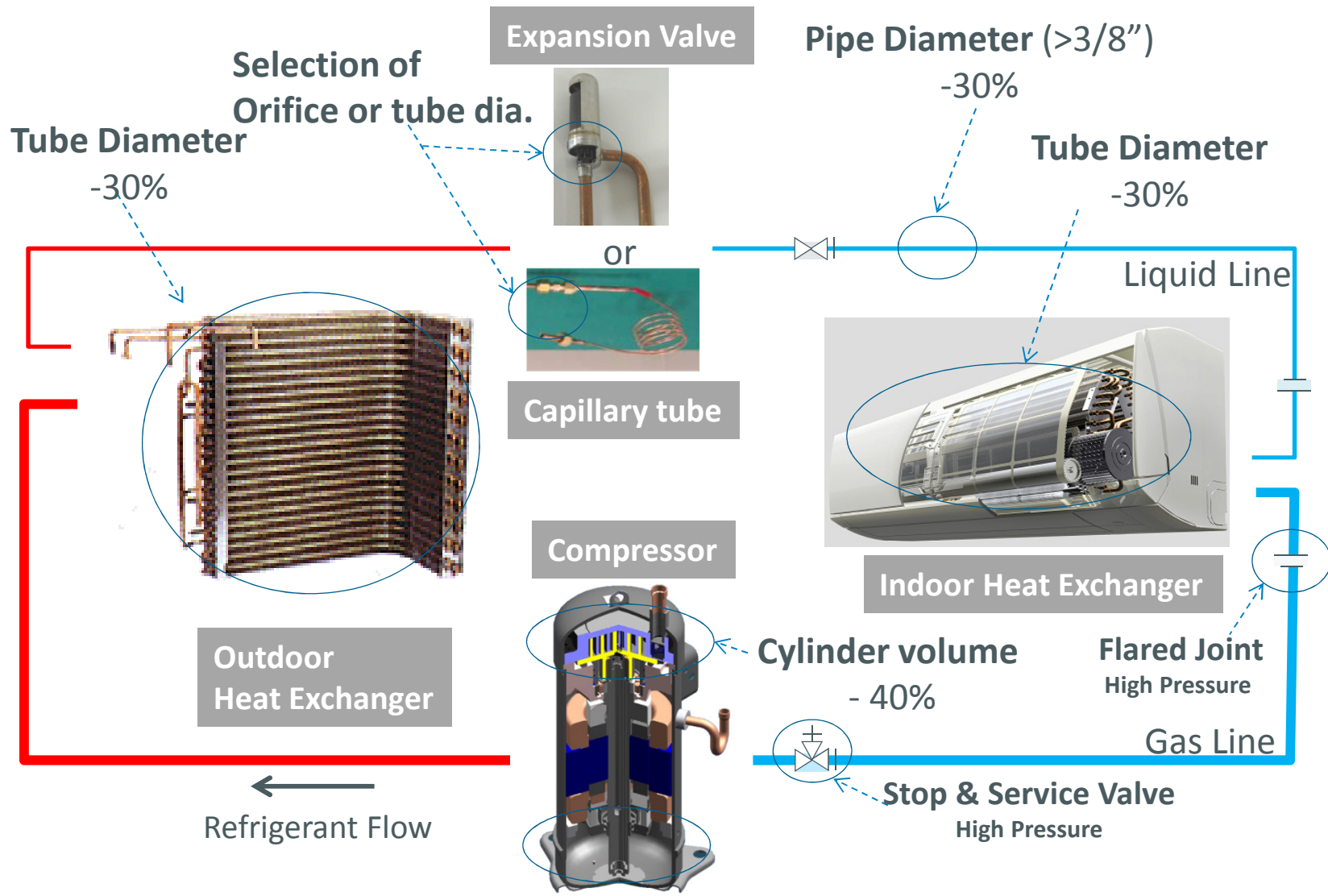
- Potential of Refrigeration capacity :1.6 times that of R410A
- Lower pressure loss, when capacity is same, leads to thinner piping diameter
- Higher coefficient of heat transfer compared to R410A
- Charge volume reduction
  - 90% of R410A due to liquid density
  - Internal volume reduction of the refrigerant circuit→ total 30% reduction against R410A





# Potential Downsizing for R32

theoretical comparison against R22/R410A

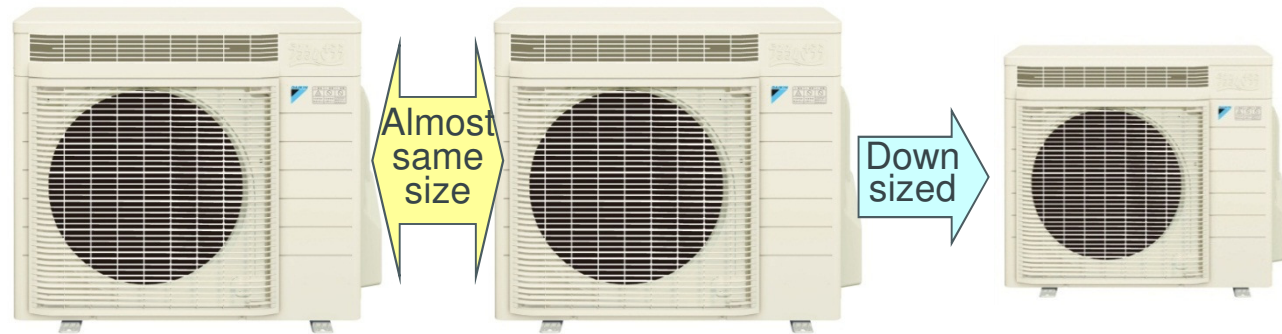




# Downsizing of Unit Size (Actual)



Unit size



Volume ratio

100%

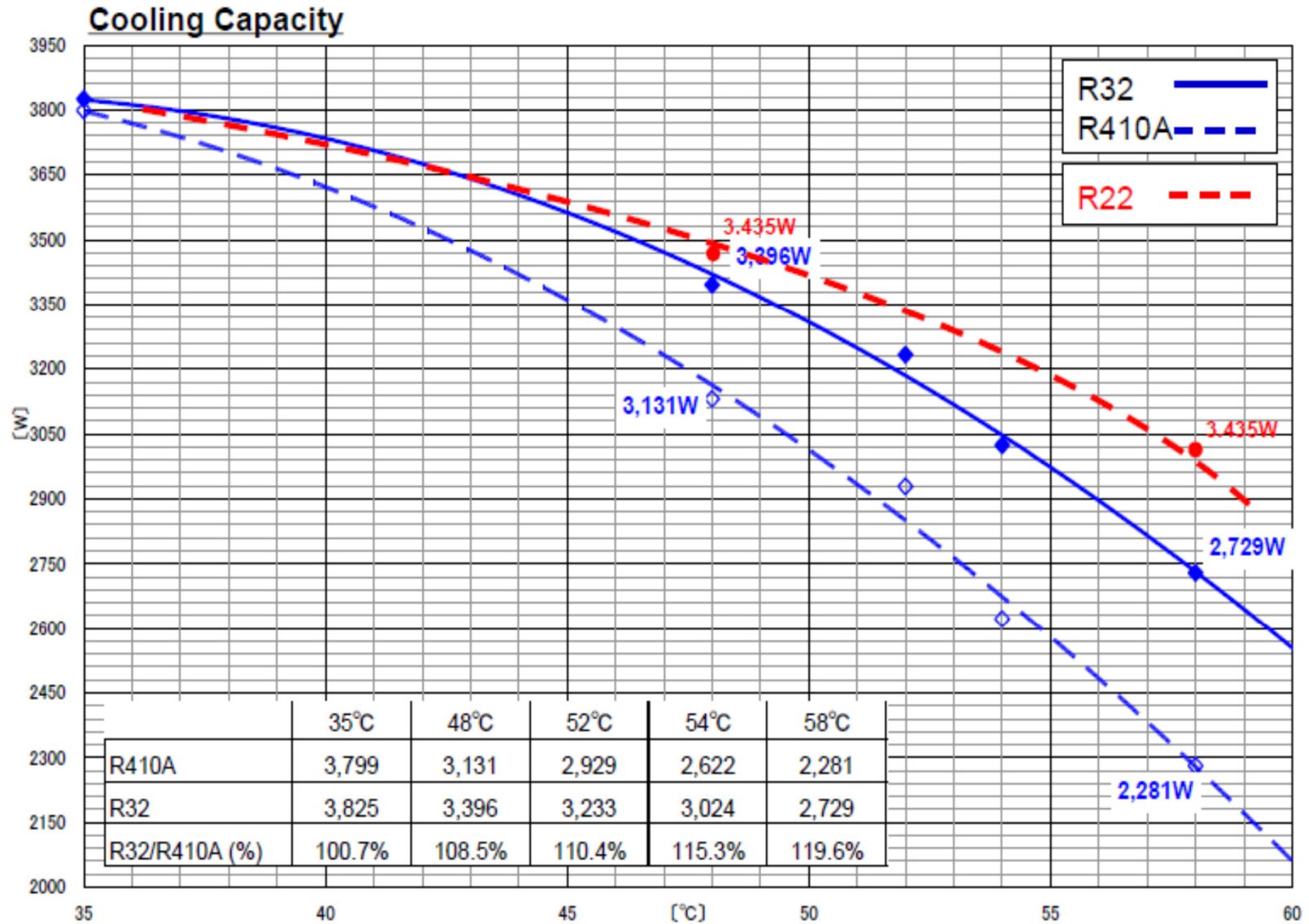
100%

85-95%

# R32 – R410A Comparison test



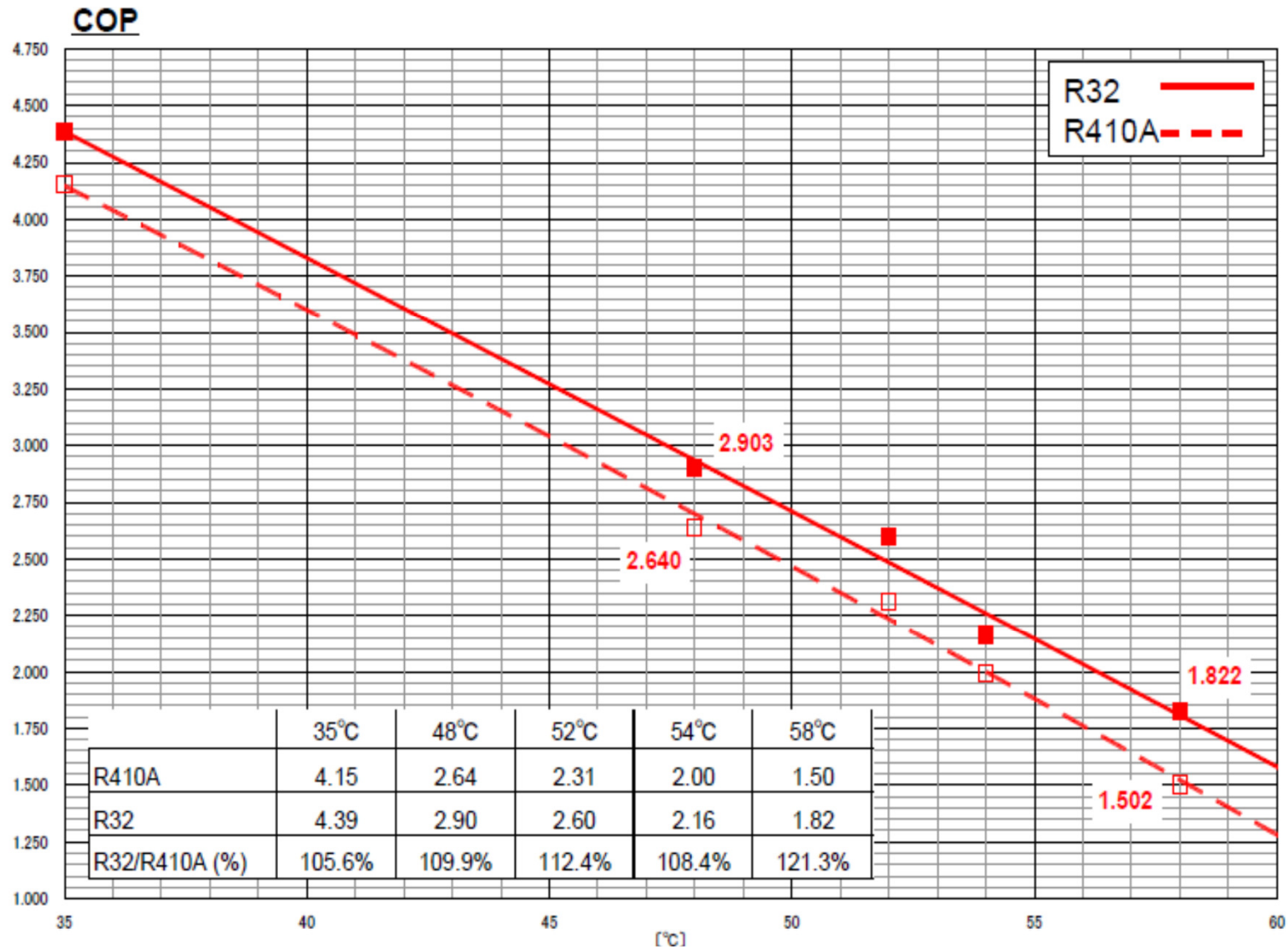
Cooling standard ~ high ambient condition



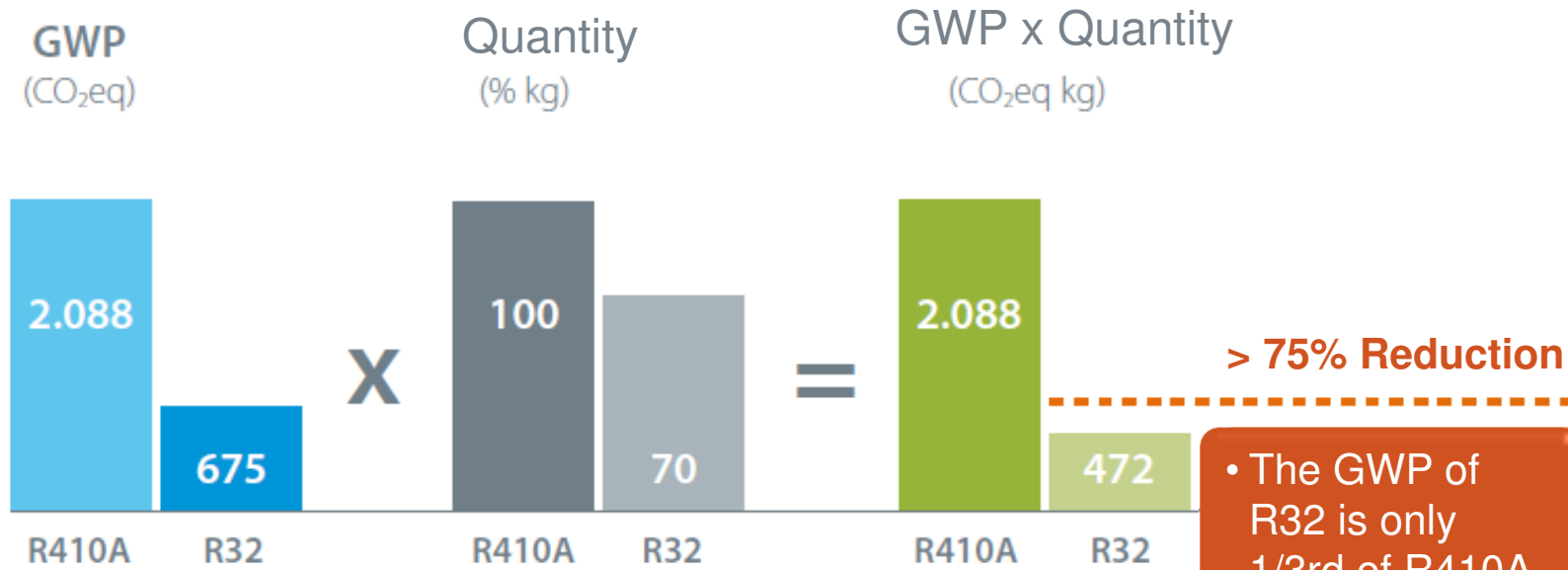
# R32 – R410A Comparison test



Cooling standard ~ high ambient condition



# Global Warming Potential of R32



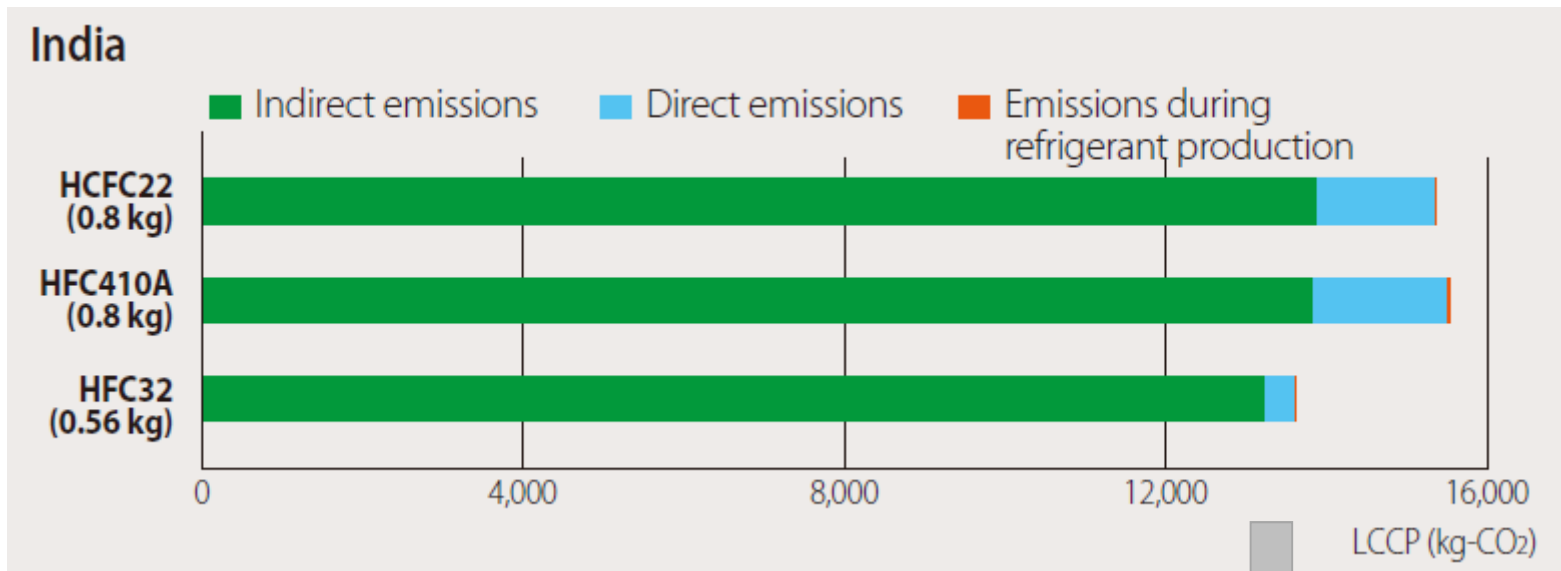
GWP Values according to IPCC 4th Assessment Report  
 For the EU F gas regulation the GWP values of IPCC 3rd report are valid  
 (R410A = 1975, R32 = 650)

- The GWP of R32 is only 1/3rd of R410A
- Taking into account the refrigerant charge, the GWP is only 1/4th !

# Global warming impact (LCCP) of R32 split systems



Total Life Cycle Climate Impact (cooling only)



## Preconditions for calculations

1. 3.5 kW split-type cooling only model
2. CSPF: ISO/DIS16358-1
3. Operating period: 8 hours/day
4. Charging volume: 0.8 kg for HCFC22 and HFC410A; 0.56 kg for HFC32
5. Recovery ratio: 0%
6. Emission intensity: 1.43 kg-CO<sub>2</sub>/kWh; Power reception level (2003) based on an assessment report by JEMA, 2006

Due to the higher energy efficiency, the total climate impact of the R32 unit is the lowest

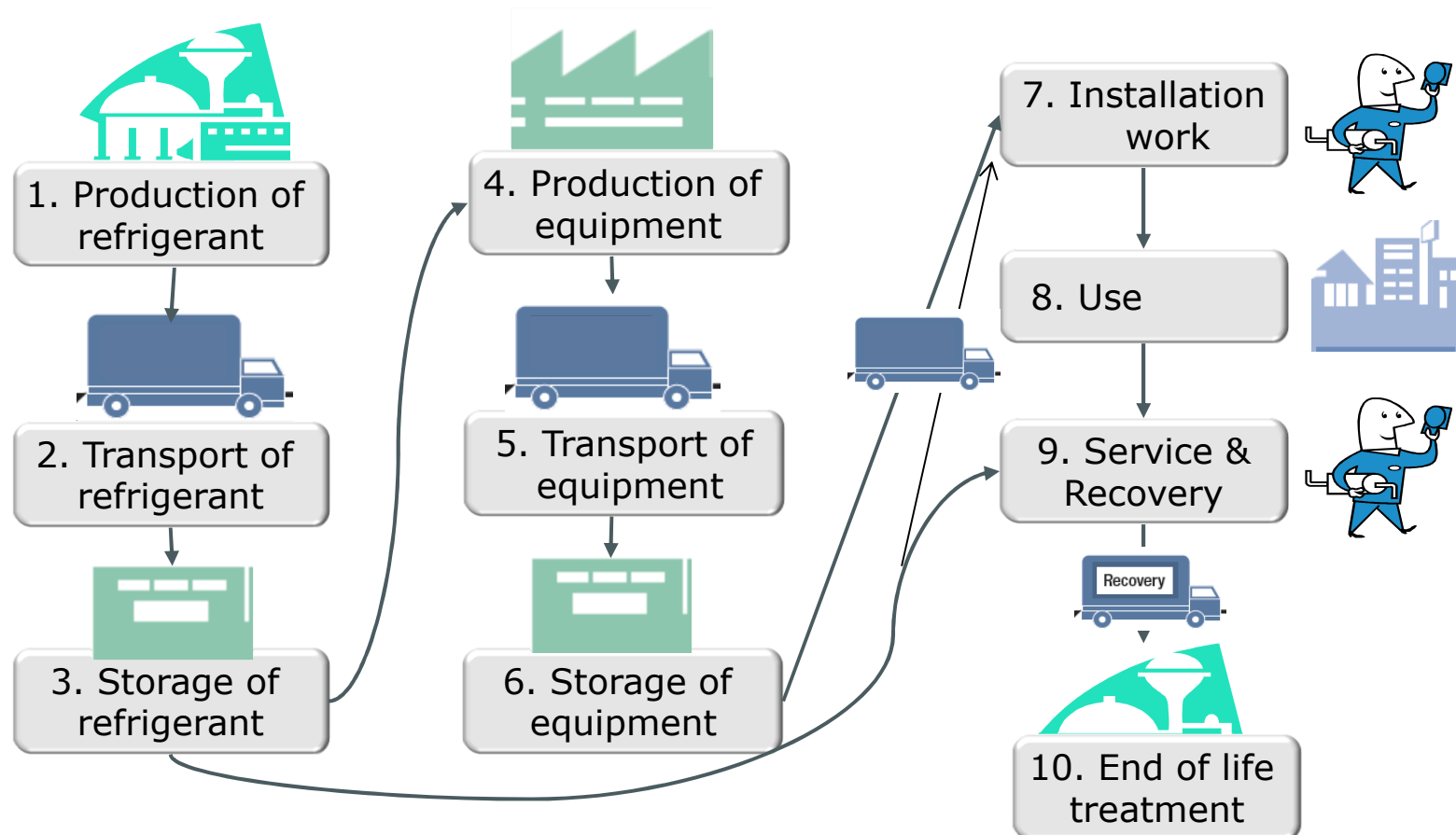
# Flammability classification of R32 = 2L

Class 1	Class 2L	Class 2	Class 3
Not flammable	Slightly flammable  burning velocity $\leq 10$ cm/s	Low flammable	Highly flammable
R744 (CO <sub>2</sub> )	R1234yf / ze	R152a	R290
R410A	<b>R32</b>		
	R717 (Ammonia)		



Flammability of 2L refrigerants is very low.  
 The burning velocity ( $\leq 10$  cm/s) is too slow to cause horizontal flame propagation or explosion.  
 Classification according to ASHRAE34 & draft ISO817.

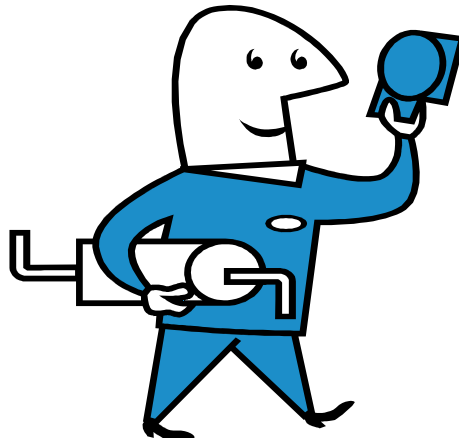
# Safety is a must during the whole life cycle !



- International, National & Local regulations & standards play a role.
- Avoid “Overspecification” : the risks of Class 2L refrigerants are much lower compared to Class 3 refrigerants !



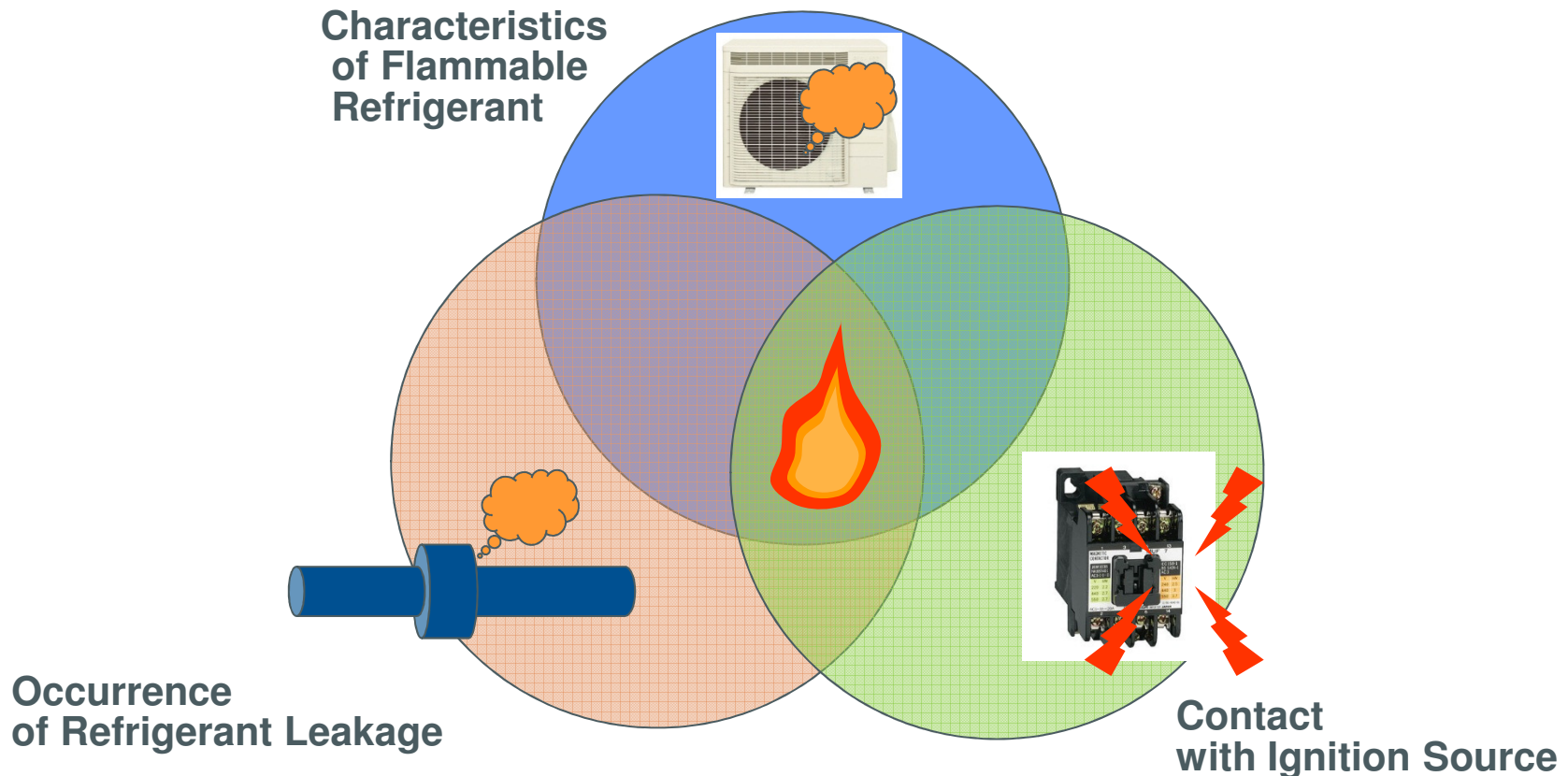
# Installation, Service and Use conditions



# Conditions for Refrigerant Ignition



- A fire accident triggered by a flammable refrigerant occurs if 3 conditions are met.
- Adequate measures must be taken to prevent the “likelihood” that such situation occurs



# Each condition needs evaluation



## 1. Assess Flammability

### Flammable Gas

- Safety class (ASHRAE) A3 A2 A2L
- LFL Low flammable Limit
- UFL Upper flammable limit
- Auto Ignition temperature
- MIE Minimum ignition energy
- BV Burning Velocity
- Heat of Combustion

## 2. Formulate Refrigerant Charge Limit Maintenance & Service training

### Refrigerant Leakage

- Internal Factor
  - Poor manufacturing quality
  - Leakage from piping, joint, Heat exchanger joint piping
- External Factor
  - Poor installation quality
  - Poor maintenance & service

## 3. Investigate ignition source impact

### Ignition Source

- Internal Factor
  - Electric Circuit Board
  - Magnet Conductor
- External Factor
  - Cigarette
  - Hot water Supply Boiler
  - Fire accident

# Example flammability behaviour of Class 3 refrigerant (R290)



30 gram R290 / 1m<sup>3</sup>

Ignited by spark

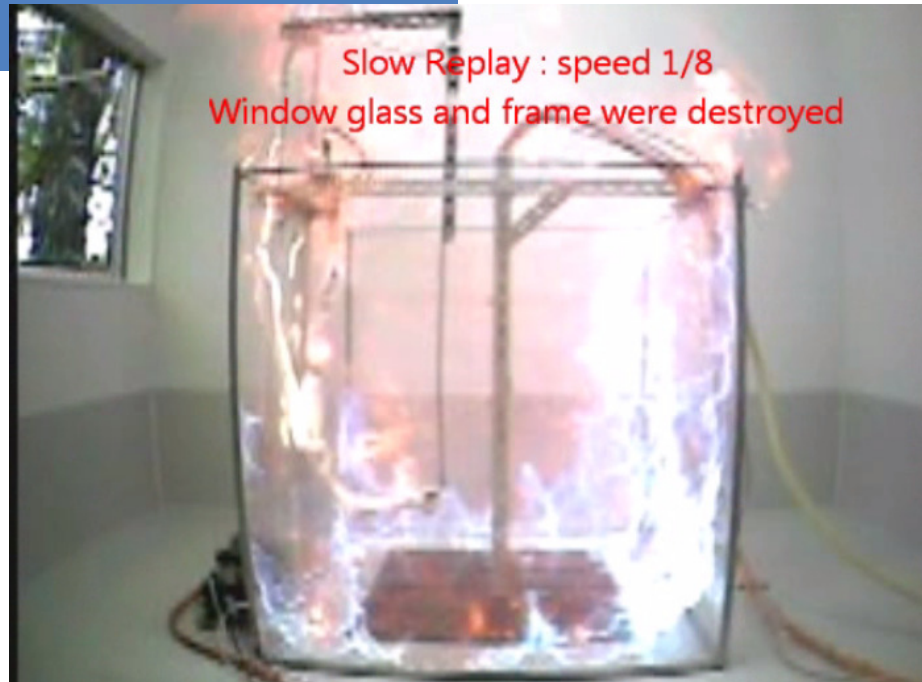
Explosion

1st STEP

Refrigerant : Propane, 30g

Ignition : Spark

Ambient : 15degC, 69%RH



Slow Replay : speed 1/8  
Window glass and frame were destroyed

# Example flammability behaviour of Class 2L refrigerant (R32)



300 gram R32 / 1m<sup>3</sup>

Ignited by flame

No fire

1st STEP

Refrigerant : R32, 300g

Ignition : Pilot Burner

Ambient : 13degC, 67%RH



# Example flammability behaviour of Class 2L refrigerant (R32)



320 gram R32 / 1m<sup>3</sup>

Ignited by flame

Slow vertical flame  
but no explosion

1st STEP

Refrigerant : R32, 320g

Ignition : Pilot Burner

Ambient : 13degC, 65%RH





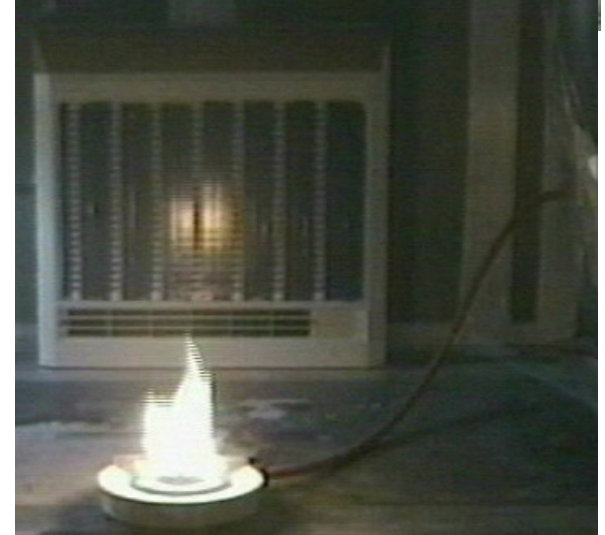
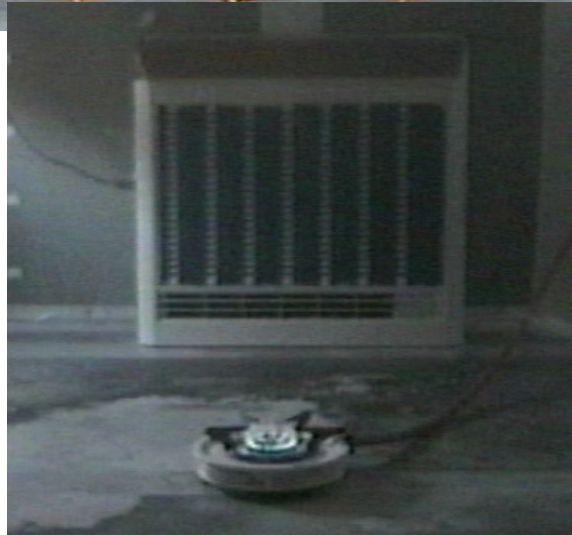
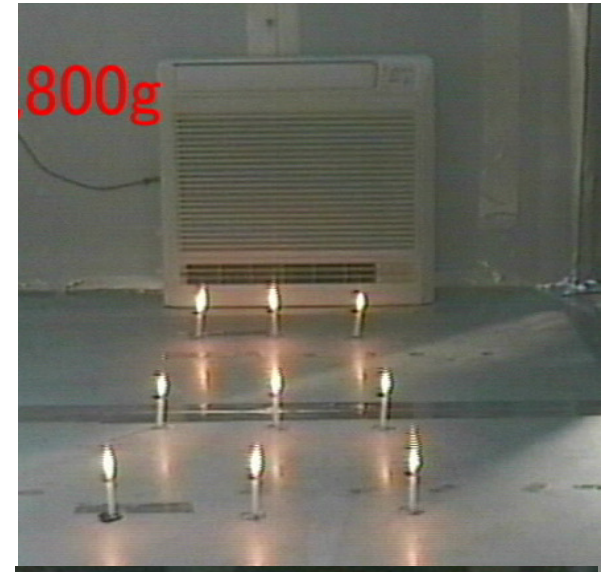
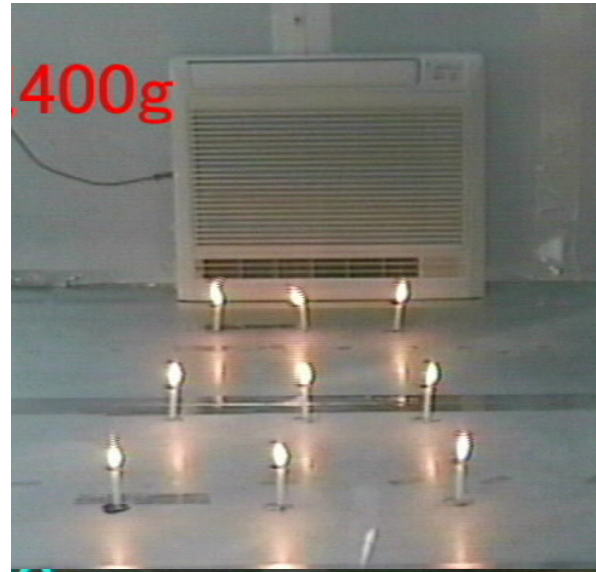
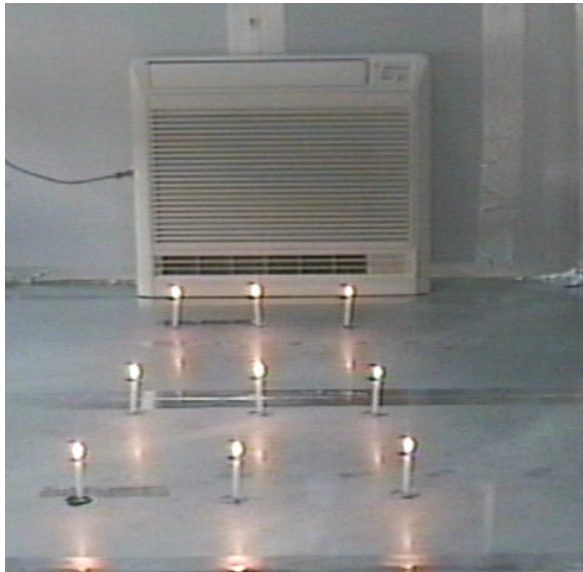
# Simulation R32 leak – no flame propagation occurs



0g

400g

800g





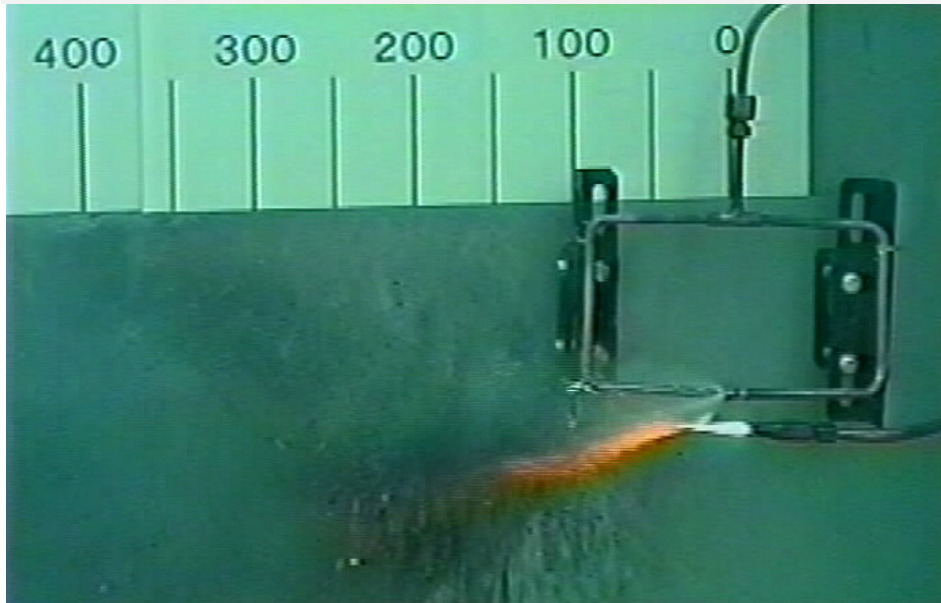
# Simulation R32 rapid leak from liquid line during brazing work



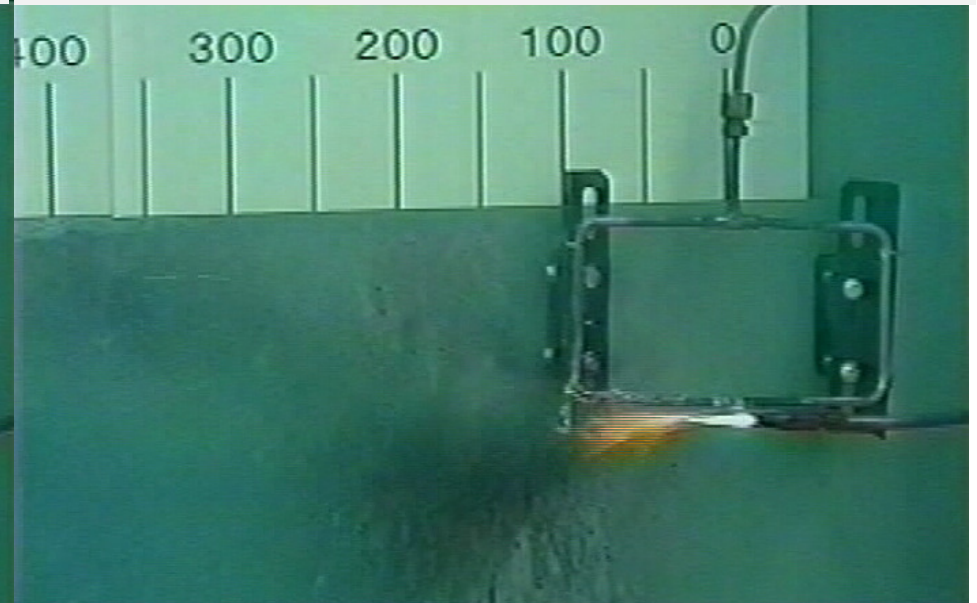
No flame propagation occurs.

Same result as R410A (due to oil)

R32+ETHER OIL (5%)



R410A+ETHER OIL (5%)



# Related Safety standards



Revision of international & European standards is ongoing

Field	International	Europe	US
Refrigerant Classification	<b>ISO817</b> Under revision	-NA- (based on ISO)	ASHRAE 34 UL 2182
Usage Restriction for Safety	<b>ISO5149</b> Under revision	<b>EN378</b> Under revision	ASHRAE 15
	<b>IEC60335-2-40</b> Under revision	EN60335-2-40 Based on IEC	UL 207 UL 250 UL 471 UL 474 UL 484 UL 984 UL 1995 UL 60335-2-40

# Publication of Japanese test results at JRAIA Symposium in Kobe, 8 & 9 November 2012



 THE JAPAN REFRIGERATION AND AIR CONDITIONING INDUSTRY ASSOCIATION (JRAIA)

 **THE INTERNATIONAL SYMPOSIUM on  
NEW REFRIGERANTS and  
ENVIRONMENTAL TECHNOLOGY 2012**

 **Tentative Program**

**Nov. 8 (Thu.) – 9 (Fri.), 2012**  
**International Conference Center Kobe,  
Main Hall, Kobe, Japan**

**Technical Session / Poster Session**

- Environment Issue
- New Refrigerants and their system
- Safety Analyses of 2L Refrigerants
- Energy Conservation
- Compressors and Lubricants
- Other Relative Technology and Research Results on Air Conditioning and Refrigeration

\*English, Japanese (Simultaneous Interpretation)



# Design changes and reliability evaluation

# Design Changes for R32 and R410A



	Flammability 燃焼性	Pressure 圧力	Discharge Temp. 吐出温度	Refrigeration Oil 冷凍機油
<b>R32</b> Residential Air-conditioner	<p>Safety Standard 安全基準</p> <p>Refrigerant Charge Service manual 冷媒充填量、サービスマニュアル</p>	<p>Pressure Design 設計圧力</p> <p>Design Pressure R32 : 4.29MPa R410A : 4.15MPa</p>	<p>Control 制御</p> <p>Control of Suction States</p>	<p>Synthetic Oil</p> <p>R32 : PVE_B R410A : PVE_A</p>
	<p>Slightly Flammable Class 2L 微燃性</p>		<p>+10 to +20 degC</p>	<p>Control of Contaminants コンタミ管理</p>
<b>R410A</b> Residential Air-conditioner				
	<p>Non-Flammable Class 1</p>	<p>1.6 times 1.6倍</p>	<p>Medium Temp.</p>	<p>Solubility 溶解性</p>
<b>R22</b> Residential Air-conditioner		<p>Medium Pressure 2.9MPa</p>		<p>Mineral Oil 鉱物油 Suniso</p>

Sealing rubber material is recommended to be changed from CR to HNBR in HFC's Equipment.

シール材はHFCの機器においてCRからHNBRへの変更を推奨

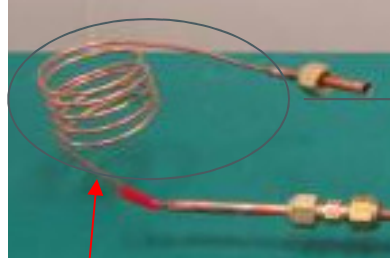


# Evaluate of Parts Reliability

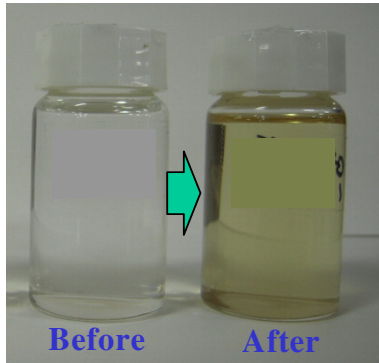


To apply R32 for new products, we must evaluate the reliability for each part of air conditioner.

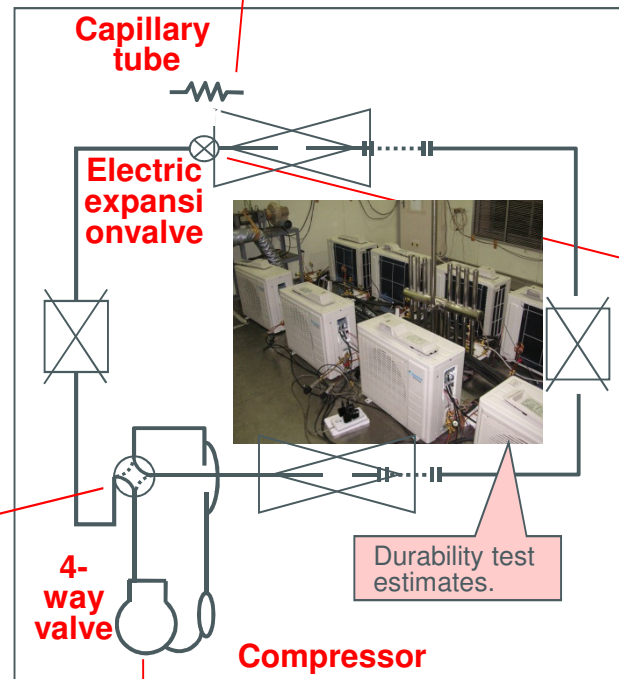
- Refrigerant oil needs lubricating ability throughout its product life.
- And it is necessary not to adversely affect other functional parts.



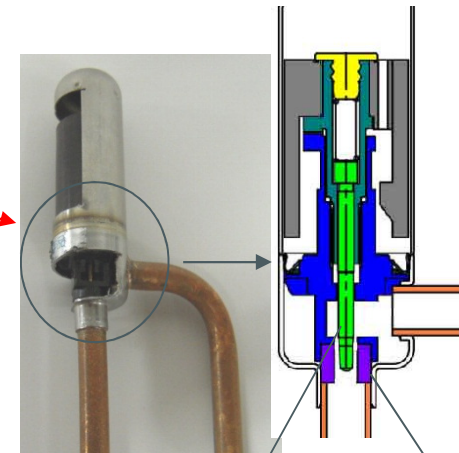
No corrosion, no erosion, no sign of clog in tube



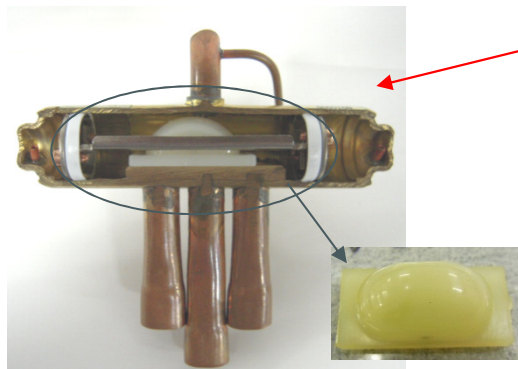
Refrigerant oil durability



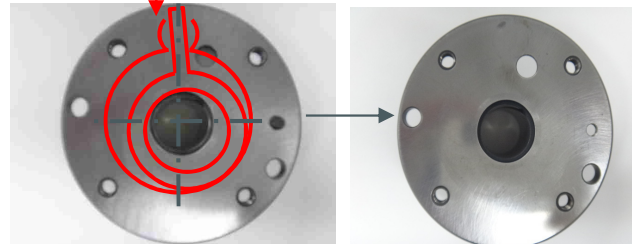
Durability test estimates.



Needle  
Seat  
No corrosion, no erosion, at needle and seat



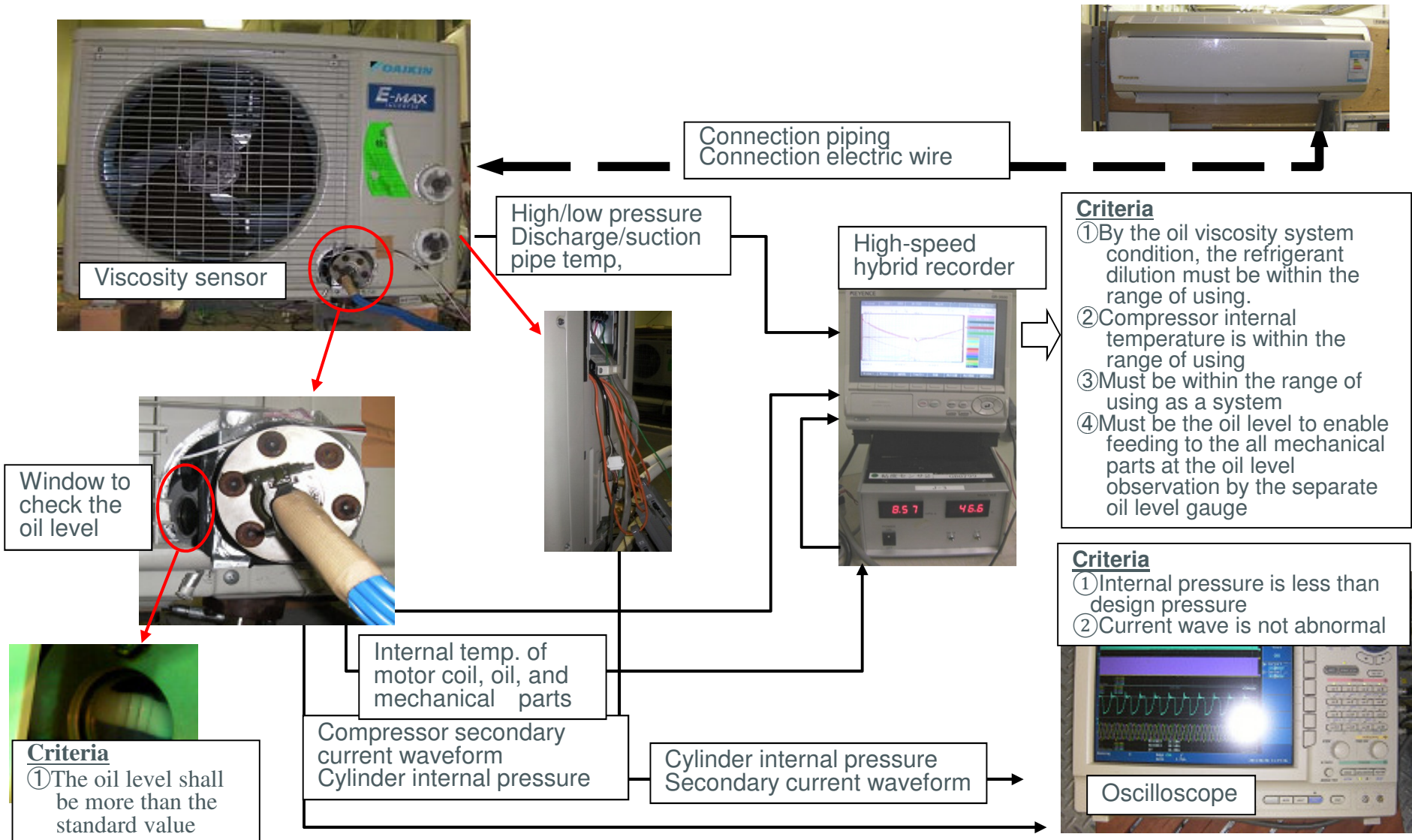
No plastic deformation



No metal contact, no rough surface

# Evaluate of System Reliability

To evaluate of reliability of the products, the following “Compressor reliability tests” are carried out.







# Daikin's Contribution

## 1. RESEARCH & DEVELOPMENT

- Move forward from R32 concept to laboratory test to field test and finally to product launch

## 2. RISK ASSESSMENT AND FLAMMABILITY TEST

- Participation of Projects in Japan, China, and US

## 3. TRAINING FOR INSTALLATION/SERVICE ENGINEERS

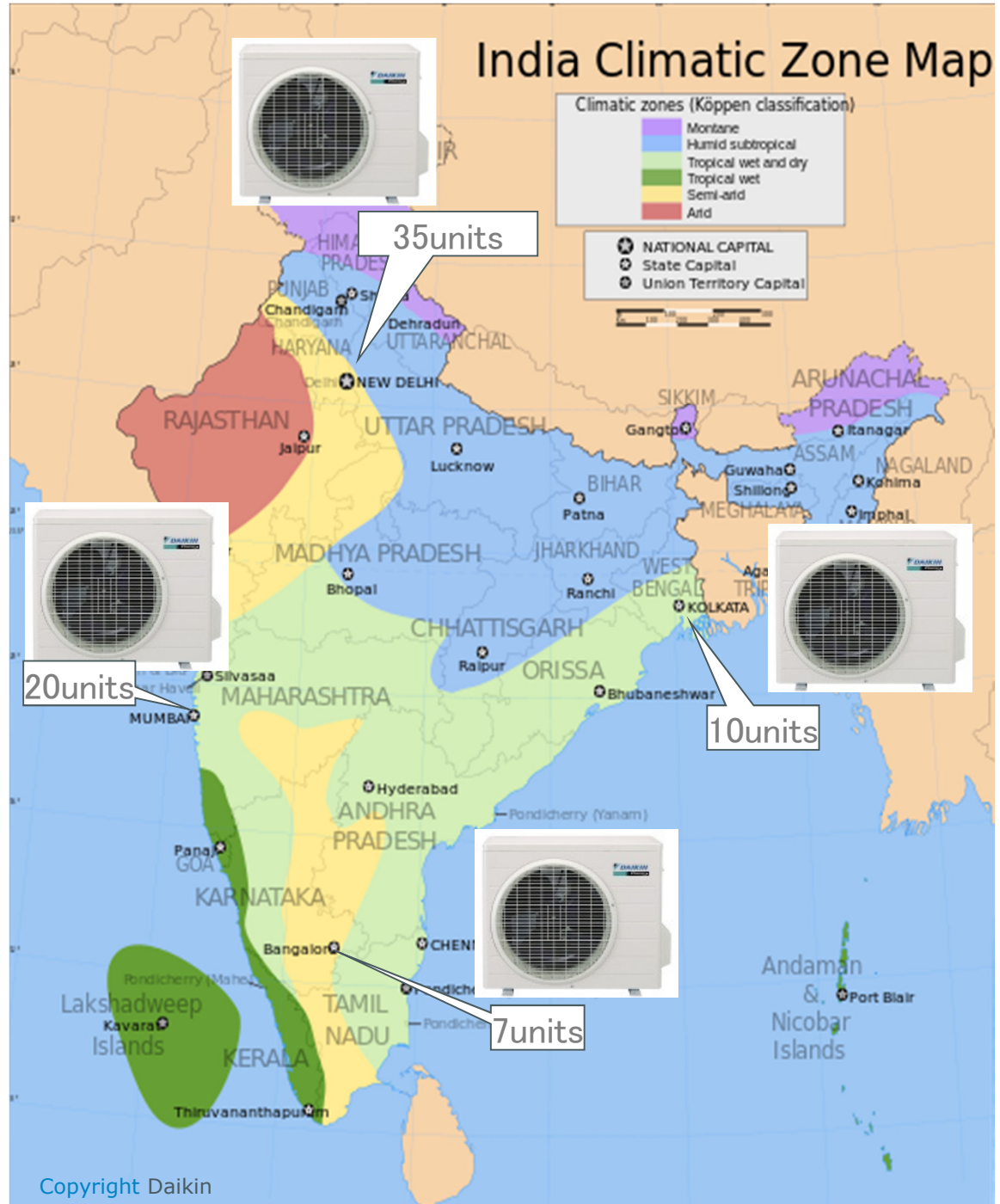
- Supporting local training seminars

## 4. PATENT RELEASE

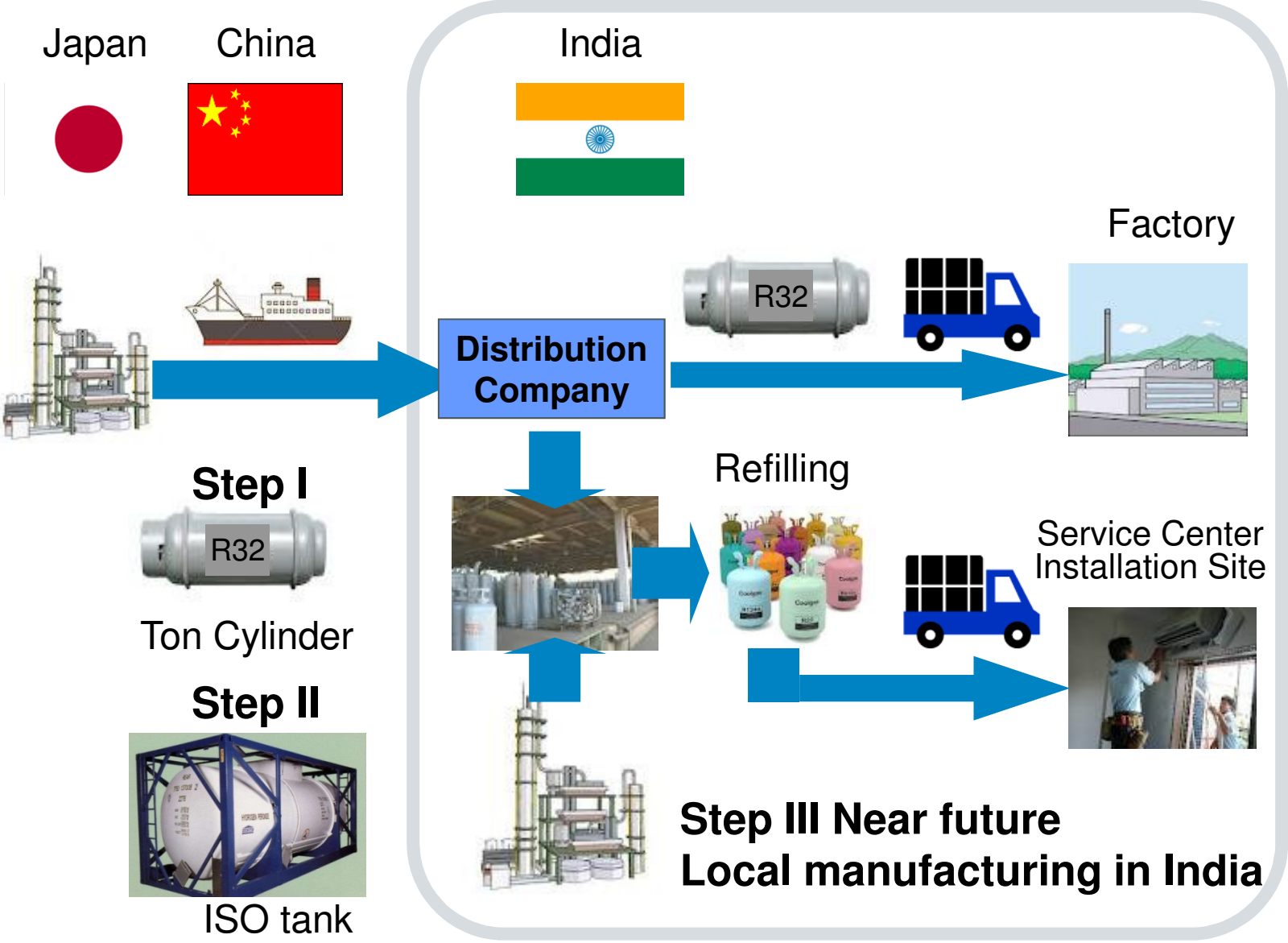
- Basic Patent release for R32 air conditioner mainly for A5 countries

# Daikin R32 field tests & training in India

Supported by Japanese Ministry for Economy, Trade & Industry



# Distribution of R32 Gas in India



# Service Manual

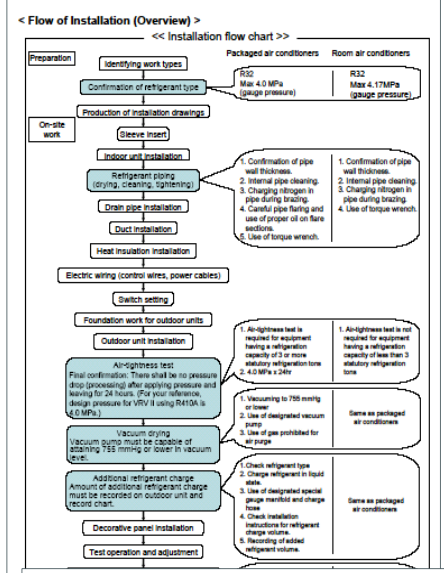


## HFC Refrigerant (R32) Compliant Systems Installation and Service Manual

August 13, 2012

DAIKIN INDUSTRIES, Ltd.  
After Sales Service Division

SM-27



### 2) Brazing (Nitrogen charge method)

- Basic works**
- Conduct brazing with the pipe end pointed downward or positioned horizontally. Do not place the pipe end upward when brazing to prevent leaks.
  - Be sure to use the designated branch joint for both liquid and gas pipes. Pay attention to the mounting direction and angle to prevent oil return and irregular flow.
  - A nitrogen gas must be supplied into the pipe during brazing.

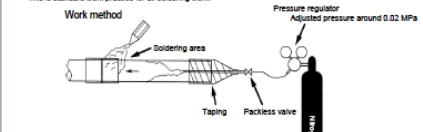
- <Cautions>**
- Take measures to prevent a possible fire (preparing the brazing site and keeping a fire extinguisher and water nearby)
  - Be careful of burning skins.
  - Check to make sure that the space between the pipe and joint is appropriate. (leak prevention)
  - Make sure that the pipe is supported properly.
- Horizontal pipes (copper pipes) should be supported at the following pitches.

Pitch of copper pipe support (Source: HASS 107-1977)

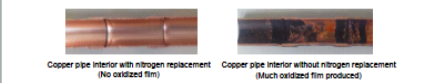
Normal diameter (mm)	23 or less	25-40	52
Maximum pitch (m)	1.0	1.5	2.0

- Do not fit the copper pipe with metal flare directly.

**[Nitrogen charge method]**  
 If soldering work is carried out without passing nitrogen gas through the pipes which are being soldered then this allows the formation of oxidation bubbles on the inside surface of the pipes. These oxidation bubbles are then carried along inside the pipes to cause damage to various members of the system such as valves or compressors and the system ceases to function properly.  
 In order to avoid this problem nitrogen is passed through the pipes while the soldering work is being carried out. This operation is known as nitrogen replacement. (N<sub>2</sub> is replaced by nitrogen)  
 This is standard work practice for all soldering work.



- <Important points>**
- The gas used must be nitrogen (oxygen, carbon dioxide and CFCs are inappropriate)
  - A pressure regulator must be used.



### 5) Flaring procedure

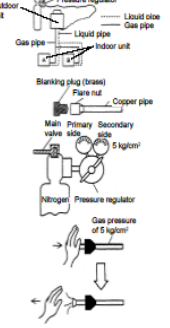
- Cut the pipe using a pipe cutter.
- Apply ether oil on the inside of the flared section. Never use mineral oil (suniso etc.)! (Be careful to keep dust away.)
- Tighten the flare nut. (Use a torque wrench to apply the proper tightening force.) 1&4 and 5/8 flare nuts for R32 and R410A equipment are enlarged across the flats. 1&4: 24mm - 26mm 5/8: 27mm - 29mm
- The cut edge has burrs. (Be careful not to let particles enter in the pipe. Point the pipe end downward during deburring.)
- Remove the burrs using a reamer. (Be careful not to let particles enter in the pipe. Point the pipe end downward during flaring.)
- Clean the inside of the pipe. (Use a thin stick with a cloth wrapped around it.)
- Before flaring, clean the cone section of the flaring tool.
- Flare the pipe. Rotate the flaring tool 3 or 4 turns after a clicking sound is produced. This results in a fine flared surface. (Refer to the next page for details.)
- Check for gas leaks. Use soapy water to check for leaks. Wipe the nut area clean when finished.
- Check that flaring has been finished correctly. (Inside of flared section should be perfectly circular and even. Do not forget to insert flare nut.)

### 4) Refrigerant pipe flushing

**Flushing removes foreign particles from the inside of pipes by means of gas pressure.**

- <Three main effects>**
- Removes oxidized film inside copper pipes generated by insufficient charging of nitrogen gas during brazing.
  - Removes foreign particles and moisture that entered pipes due to inadequate preparation.
  - Confirms connection of pipes between indoor and outdoor units (for both liquid and gas pipes).

- [Procedure]**
- Mount a pressure reducing valve on the nitrogen cylinder. (Be sure to use a nitrogen gas. (Dew condensation may occur if a CFC or carbon dioxide gas is used. Oxygen gas may cause an explosion.)
  - Connect the charge hose of the pressure reducing valve to the service port of the liquid pipe of the outdoor unit.
  - Mount a blind plug on indoor unit (B). Do not mount a blind plug on indoor unit A.
  - Open the main valve of the nitrogen cylinder, and adjust the pressure reducing valve until the pressure becomes 0.5 MPa.
  - Make sure that the nitrogen gas is released through the liquid pipe of indoor unit A.



- Flushing - Close the pipe end with the palm of the hand. (When the pressure becomes high, move the hand quickly.) (1st flushing)
- Close the pipe end with the palm of the hand again. (Conduct the 2nd flushing.)

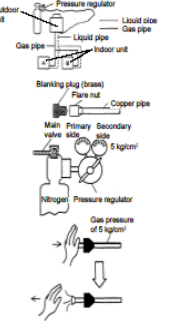
**<The nature and amount of the extraneous material inside the pipe can be checked during flushing by placing a rag lightly over the end of the pipe. In the unlikely case that even a small quantity of moisture is found then the inside of the pipe should be dried out thoroughly.>**  
**Action:** (1) Flush the inside of the pipe with nitrogen gas. (Until such time as the moisture disappears.) (2) Carry out a thorough vacuum drying operation. -<See 7) Vacuum drying->

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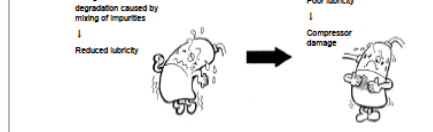


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**● What happens if an R32 unit was charged with SUNISO oil (mineral oil)?**

**Ether oil can degrade and clogging occurs due to poor lubricity in the compressor and sludge development. This can cause machine failure.**



### 11) Safety Precautions

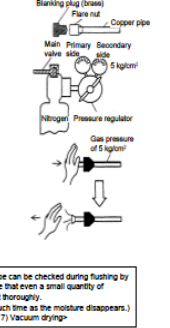
- Cautions concerning the high pressure of R32
  - ⇒ For example, if the charge hose detaches from the service port while there is still R32 inside, it can cause the charge hose to violently shake or the refrigerant to squirt out.
- Cautions regarding ventilation
  - ⇒ Ensure proper ventilation in order to keep the R32 concentration within a tolerable level in the work environment.
  - R32 tends to settle in lower places due to it being heavier than air. If the room or lower place becomes highly charged with R32 due to a gas leak, it can reduce oxygen levels to below the level necessary for humans to function, causing symptoms of oxygen deficiency. Accumulated R32 may also cause the gas to reach the combustion concentration range (slightly flammable state). For the above reasons, ensure proper ventilation.
- Precautions when performing electrical work and replacing electric components
  - To avoid fires, and also to prevent electric shocks, when working with electric components or performing electrical work, take extreme care that sparks do not cause fire (or act as ignition sources).
  - ⇒ Always ensure that switches have been turned off first before starting work. When working, always check that the power supply has been cut off using a tester. (Never ask the customer to do this or check that this has been done, and never cut off the power without asking first.)
  - ⇒ If there is still power in capacitors after the power has been cut off, always earth (discharge) them in a safe manner that will not generate sparks before performing any work.
  - ⇒ Never perform work when a refrigerant leakage has been confirmed; always ensure that the area has been appropriately ventilated and that the work environment has been improved before performing any work.

### 4) Refrigerant pipe flushing

**Flushing removes foreign particles from the inside of pipes by means of gas pressure.**

- <Three main effects>**
- Removes oxidized film inside copper pipes generated by insufficient charging of nitrogen gas during brazing.
  - Removes foreign particles and moisture that entered pipes due to inadequate preparation.
  - Confirms connection of pipes between indoor and outdoor units (for both liquid and gas pipes).

- [Procedure]**
- Mount a pressure reducing valve on the nitrogen cylinder. (Be sure to use a nitrogen gas. (Dew condensation may occur if a CFC or carbon dioxide gas is used. Oxygen gas may cause an explosion.)
  - Connect the charge hose of the pressure reducing valve to the service port of the liquid pipe of the outdoor unit.
  - Mount a blind plug on indoor unit (B). Do not mount a blind plug on indoor unit A.
  - Open the main valve of the nitrogen cylinder, and adjust the pressure reducing valve until the pressure becomes 0.5 MPa.
  - Make sure that the nitrogen gas is released through the liquid pipe of indoor unit A.



- Flushing - Close the pipe end with the palm of the hand. (When the pressure becomes high, move the hand quickly.) (1st flushing)
- Close the pipe end with the palm of the hand again. (Conduct the 2nd flushing.)

**<The nature and amount of the extraneous material inside the pipe can be checked during flushing by placing a rag lightly over the end of the pipe. In the unlikely case that even a small quantity of moisture is found then the inside of the pipe should be dried out thoroughly.>**  
**Action:** (1) Flush the inside of the pipe with nitrogen gas. (Until such time as the moisture disappears.) (2) Carry out a thorough vacuum drying operation. -<See 7) Vacuum drying->

**● What happens if an R32 unit was charged with SUNISO oil (mineral oil)?**

**Ether oil can degrade and clogging occurs due to poor lubricity in the compressor and sludge development. This can cause machine failure.**

- Close the main valve of the nitrogen cylinder.
- Repeat the same procedure for indoor unit B.
- After completing the flushing for the liquid pipes, conduct flushing for the gas pipes.



# Collaboration with India



~ Path-breaking development about this technology ~

*June, 2011*

Under METI of Japan's leadership, Panasonic and Daikin agreed to help Indonesia introduce this technology early June.

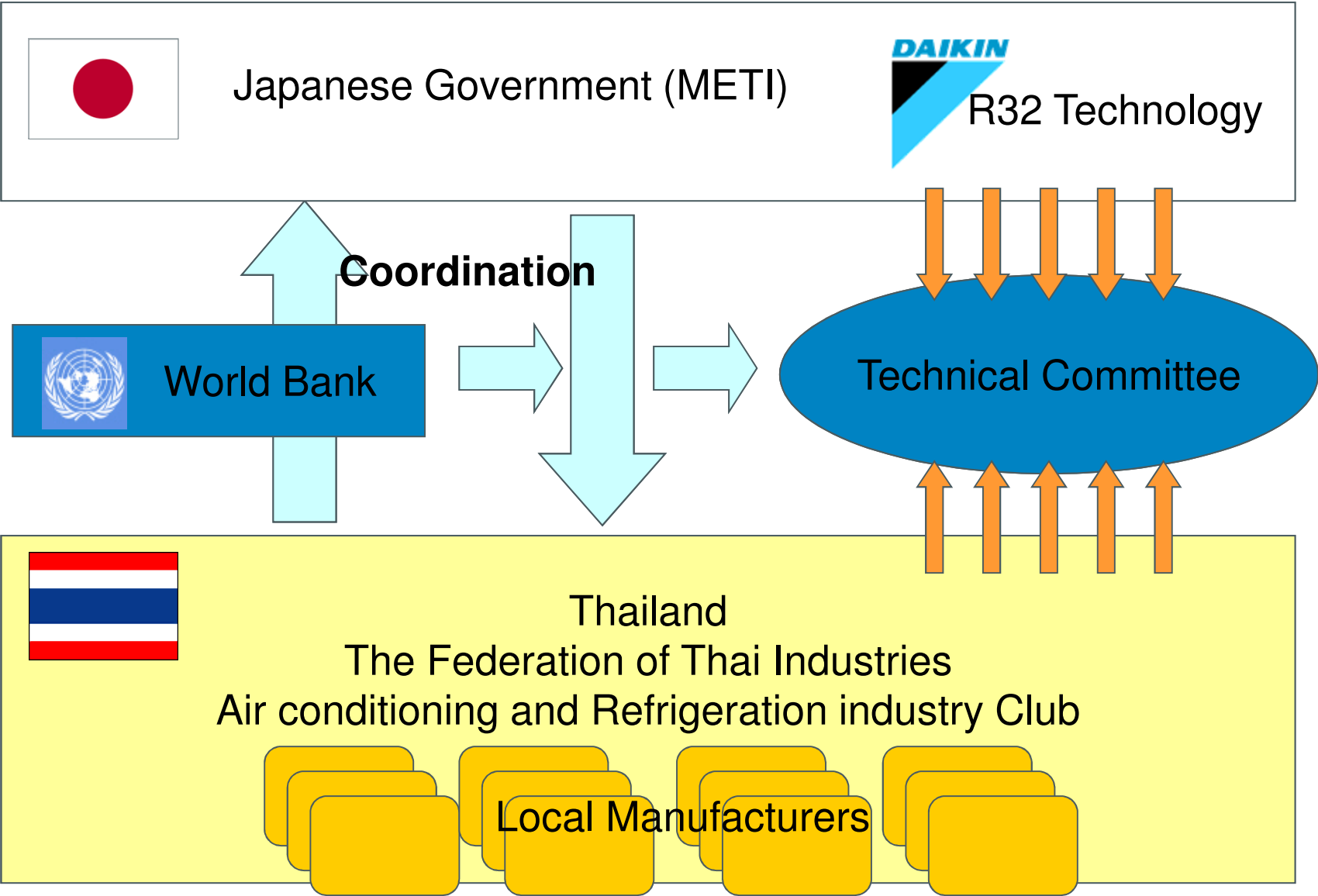
Within weeks of the above agreement, Fujitsu General, Hitachi and Toshiba joined the partnership to introduce and promote R-32.



**→ Japanese Industry-Government Partnership**



# Collaboration Scheme with Thailand







# Potential Suppliers of R32 Compressor

# Potential Suppliers of R32 Compressor



**CRH2012/Beijing**



**DAIKIN**



**SANYO**



- 针对环保、节能理念设计
- R32环保冷媒压缩机GWP值更低
- R32环保冷媒压缩机能效更高
- Design for environmental-protection and energy-saving
- GWP of R32 environmental friendly air-conditioner compressor is lower
- COP of R32 environmental friendly air-conditioner compressor is higher

**GMCC**



Start preparing for the R32 phase-in now. Danfoss supports you with 20 years of experience in flammable refrigerant-based applications and a range of R32-adapted products:

- Heat exchangers
- Thermostatic expansion devices
- Compressors
- Line components: filter driers, sight glasses, check valves, ball valves

**DANFOSS**

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COMPRESSOR USING R32  
R32 压缩机

- 环境友好
- 使用新工质R32
  - 臭氧层破坏潜能值(GWP)为0
  - 全球变暖潜能为600
- 技术领先
- 采用优化的设计
  - 采用优化的设计
- 应用广泛
- 系列
  - 制冷量范围: 3700-7500W

**HITACHI**



## Daikin press release 27 Sept 2012 launch of world's first **R32** air conditioner on the Japanese market

- › Daikin considers that **R32** is suitable for split air conditioners and heat pumps
- › From fall 2012, Daikin will start to adopt **R32** to all successive models of residential air conditioners in Japan
- › Daikin aims to expand use of **R32** to commercial air conditioning equipment in the future



新モデル機(2.2kW)

H600\*W718\*D315

質量 33kg

Thank you !

