

## Introduction

- [Subject system]** Commercial package air conditioners using A2L  
**[Refrigerants (A2L)]** R32, R1234yf, R1234ze(E)  
**[Conditions of risk assessment]**
- 1<sup>st</sup> step:** Standard case  
(IU)Ceiling cassette, (OU) Ground, No additional refrigerant charge
  - 2<sup>nd</sup> step:** Higher risk case less than 14kW system  
(IU)All type excluding floor mounted, (OU) each floor installation, **semi-underground, narrow space**, (Max amount) **Additional refrigerant charge on site**
  - 3<sup>rd</sup> step:** Higher risk case less than 30kW system  
(IU)All type **including floor mounted**, (OU) each floor installation, **semi-underground, narrow space**, (Max amount) **Additional refrigerant charge on site**
- ※(IU): Indoor units, (OU): Outdoor units

## Conclusion

- Standard case** : No problem without additional safety measures
- Higher risk case** : Some conditions need the following safety measure

Risk cases	< Dominant risk factors >		Usage stage	Installation/ Service stages	Disposal stage
Floor-stand indoor units	Cause	Leakage gas retention	Leakage gas retention	Human error	-
	Factor	High concentration	Air circulation by fan	Gas burner (brazing)	-
	<b>Safety measures</b>	"Unit's fan operating with a leak detector" (Min. air flow: 10m <sup>3</sup> /min and Min. velocity: 1.0m/s)		"Education for workers" and "Carrying a portable leak detector"	
Outdoors Semi-underground installation	Cause	Leakage gas retention	Ignition sources	Human error	
	Factor	Air circulation/Ventilation	Boiler	Refrigerant recovery Gas burner	Refrigerant recovery Electrical wiring
	<b>Safety measures</b>	"Unit's fan operating with a leak detector" (Minimum air velocity: 4.0m/s)		"Education for workers" and "Carrying a leak detector"	
Outdoors Narrow space installation	Cause	Leakage gas retention	Ignition sources	Human error	
	Factor	Air circulation/Opening	Boiler	Refrigerant recovery Gas burner	Refrigerant recovery Electrical wiring
	<b>Safety measures</b>	"Opening of 0.6 m or more for one side"		"Education for workers" and "Carrying a portable leak detector"	

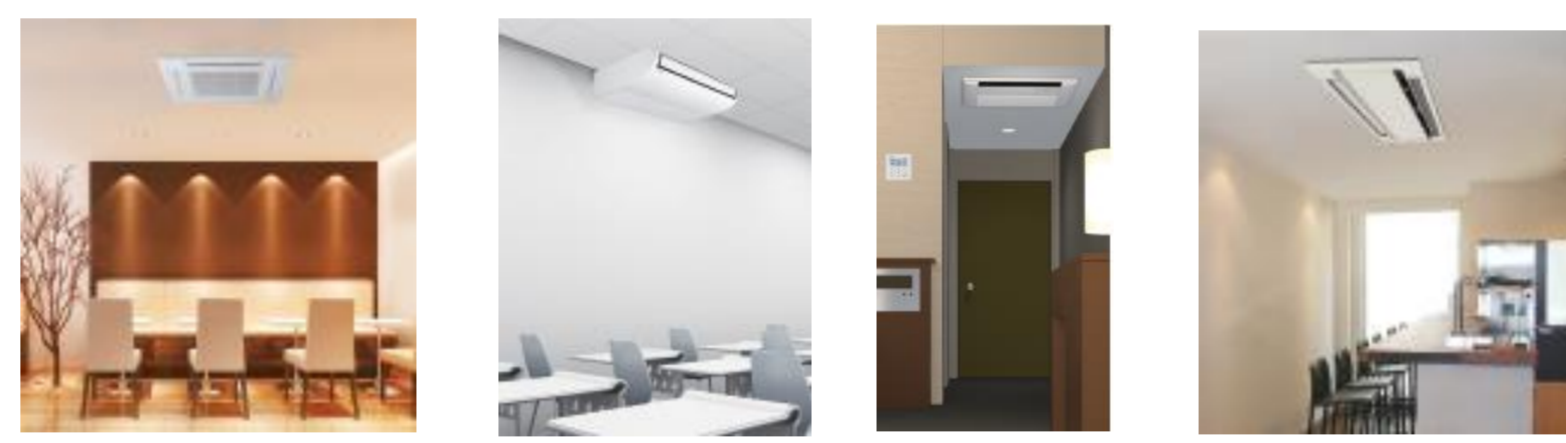
## System

- Cooling capacity:** 3.6 ~ 30.0 kW
- Charge amount of refrigerant:** 2 ~ 19Kg
- Type:** indoor single or 2~4 units in one room [simultaneous ON/OFF], outdoor single



## Installation

- Total number of unit :** about 0.6 billion units in Japan
- User :** Office, Store, School, etc. (light commercial)



## Risk case

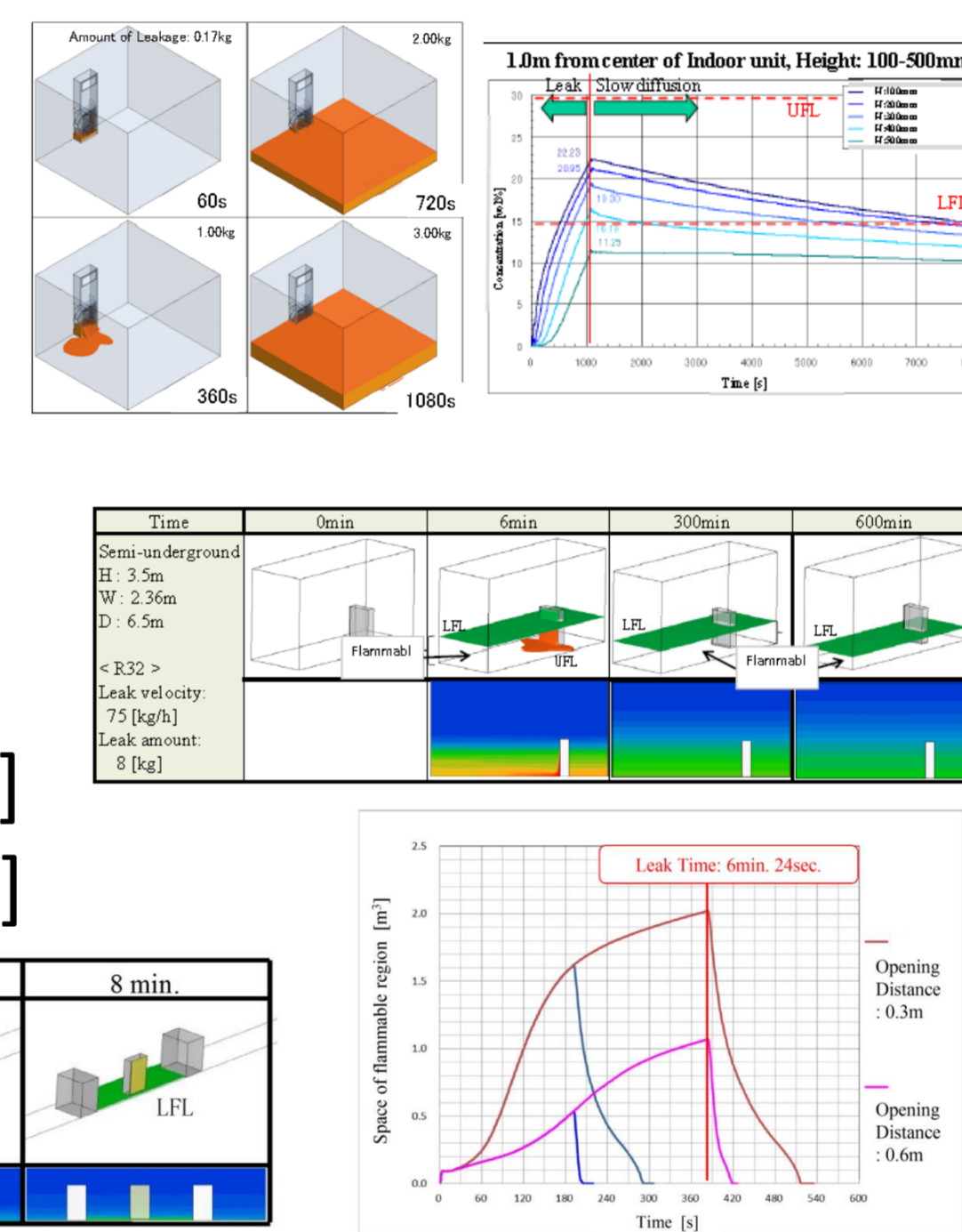
- [Indoor]**
- Floor mounted type indoor unit
- [Outdoor]**
- Semi-underground installation
  - Narrow space installation

## Leak rate

- [Indoor unit]**
- 1.03 × 10<sup>-3</sup> for slow leakage
  - 1.50 × 10<sup>-5</sup> for rapid leakage
- [Outdoor unit]**
- 6.13 × 10<sup>-2</sup> for slow leakage
  - 1.34 × 10<sup>-3</sup> for rapid leakage
  - 1.37 × 10<sup>-4</sup> for burst leakage
- [Human error (by worker)]**
- 1.0 × 10<sup>-3</sup>

## Flammable volume-time integration

- [Indoor]**
- (Cassette 14kW, 57.2m<sup>2</sup>, R32:8kg) 1.53 × 10<sup>-1</sup> [m<sup>3</sup>min]
  - (**Floor** 5kW, 14m<sup>2</sup>, R32:3kg, **Fan:OFF**) **3.23 × 10<sup>2</sup>** [m<sup>3</sup>min]
  - (**Floor** 5kW, 14m<sup>2</sup>, R32:3kg, **Fan:ON**) None
- [Outdoor]**
- (Ground 14kW, 50m<sup>2</sup>, R32:8kg) 2.80 × 10<sup>-1</sup> [m<sup>3</sup>min]
  - (**Semi-underground**, 15m<sup>2</sup>, R32:8kg) **5.97 × 10<sup>3</sup>** [m<sup>3</sup>min]
  - (**Narrow[open0.3m]**, 7.5m<sup>2</sup>, R32:8kg) **9.75 × 10<sup>0</sup>** [m<sup>3</sup>min]
  - (**Narrow[open0.6m]**, 7.5m<sup>2</sup>, R32:8kg) **3.75 × 10<sup>0</sup>** [m<sup>3</sup>min]



## Ignition source

- [Spark]**
- Match, Oil lighter
  - Metal spark (by forklift)
  - (Ref.) No ignition -
  - Gas lighter
  - Power Outlet
  - Static electricity (by human)
- [Open flame]**
- Smoking equipment
  - Combustion equipment (Heater, Boiler, Cooker etc.)
  - Gas burner (for brazing)

## Risk assessment

**[Standard case (Refrigerant: R32)]**  
< RA Condition >

Condition	Type	Location	Feature	Installation space		Capacity (kW)	Piping length (m)	Charge amount (kg)
				Floor area(m <sup>2</sup> )	Height (m)			
Indoor	Ceiling cassette	Office	Opening for natural ventilation	42.3	2.7	7.1	≤30	3
Outdoor	Side flow	Ground	Open all four sides	50	2	14.0	≤30	4
Storage	Bulk	Warehouse	2300 units	1000	-	14.0	-	4

< Result: Probability of Ignition > □ Tolerable, ■ Not tolerable

Life stage [Tolerable level]	Logistics [ ≤ 1.3×10 <sup>-8</sup> ]		Installation [ ≤ 1.3×10 <sup>-8</sup> ]		Usage [ ≤ 1.3×10 <sup>-9</sup> ]		Repair/Service [ ≤ 1.3×10 <sup>-8</sup> ]		Disposal [ ≤ 1.3×10 <sup>-8</sup> ]	
	without	with	without	with	without	with	without	with	without	with
<b>Safety measures</b>	Without	with	without	with	without	with	without	with	without	with
(Indoors) Office	-	-	6.59×10 <sup>-10</sup>	None	3.37×10 <sup>-12</sup>	None	1.19×10 <sup>-10</sup>	None	3.12×10 <sup>-12</sup>	None
(Outdoors) Ground	-	-	6.73×10 <sup>-10</sup>	None	6.35×10 <sup>-11</sup>	None	2.23×10 <sup>-10</sup>	None	6.05×10 <sup>-11</sup>	None
Warehouse	1.55×10 <sup>-11</sup>	None	-	-	-	-	-	-	-	-

**[Higher risk case (Refrigerant: R32)]**  
< RA Condition >

Condition	Type	Location	Feature	Installation space		Capacity (kW)	Piping length (m)	Charge amount (kg)
				Floor area(m <sup>2</sup> )	Height (m)			
Indoors	Ceiling	Office	Max charge	169	2.7	30.0	120	19
		Kitchen	Ignition sources	80	2.7	30.0	120	19
		Karaoke-room	tightness	9.7	2.4	3.6	50	3
	<b>Floor</b>	<b>Restaurant</b>	Leakage gas retention	14	2.5	4.5	50	3
Indoors (Ice)	Ceiling	Office	Charge rate	50	2.7	14.0	75	9
Outdoors	Side flow	Ground	Open all four sides	50	2.5	30.0	120	19
		Each floor	Close three sides	3.6	4	30.0	120	19
		<b>Semi-UG</b>	Close four sides	15.3	3.54	30.0	120	19
		<b>Narrow S</b>	Open one side(small)	7.5	2.5	30.0	120	19
Storage	Bulk	Warehouse	2300units	1000	-	30.0	-	7

< Result: Probability of Ignition > □ Tolerable, ■ Not tolerable

Life stage [Tolerable level]	Logistics [ ≤ 1.3×10 <sup>-8</sup> ]		Installation [ ≤ 1.3×10 <sup>-8</sup> ]		Usage [ ≤ 1.3×10 <sup>-9</sup> ]		Repair/Service [ ≤ 1.3×10 <sup>-8</sup> ]		Disposal [ ≤ 1.3×10 <sup>-8</sup> ]	
	without	with	without	with	without	with	without	with	without	with
<b>Safety measures</b>	without	with	without	with	without	with	without	with	without	with
Indoors										
Office	-	-	6.61×10 <sup>-10</sup>	None	7.61×10 <sup>-13</sup>	None	4.82×10 <sup>-12</sup>	None	1.90×10 <sup>-12</sup>	None
Kitchen	-	-	6.75×10 <sup>-10</sup>	None	7.97×10 <sup>-11</sup>	None	1.65×10 <sup>-10</sup>	None	7.33×10 <sup>-12</sup>	None
karaoke	-	-	6.77×10 <sup>-10</sup>	None	8.71×10 <sup>-11</sup>	None	1.04×10 <sup>-9</sup>	None	2.04×10 <sup>-11</sup>	None
<b>Restaurant</b>	-	-	1.70×10 <sup>-8</sup>	2.45×10 <sup>-10</sup>	9.39×10 <sup>-9</sup>	1.00×10 <sup>-12</sup>	9.28×10 <sup>-9</sup>	2.81×10 <sup>-9</sup>	2.99×10 <sup>-9</sup>	None
factory	-	-	2.30×10 <sup>-9</sup>	None	1.05×10 <sup>-9</sup>	None	3.11×10 <sup>-9</sup>	None	7.04×10 <sup>-10</sup>	None
Ice TS	-	-	6.68×10 <sup>-10</sup>	None	3.62×10 <sup>-12</sup>	None	4.10×10 <sup>-11</sup>	None	2.79×10 <sup>-12</sup>	None
Outdoors										
Ground	-	-	8.02×10 <sup>-10</sup>	None	2.61×10 <sup>-10</sup>	None	5.53×10 <sup>-10</sup>	None	7.60×10 <sup>-10</sup>	None
Each floor	-	-	1.00×10 <sup>-9</sup>	None	6.15×10 <sup>-10</sup>	None	1.48×10 <sup>-9</sup>	None	2.01×10 <sup>-9</sup>	None
<b>Semi underground</b>	-	-	3.67×10 <sup>-7</sup>	5.64×10 <sup>-9</sup>	4.65×10 <sup>-6</sup>	1.14×10 <sup>-9</sup>	1.18×10 <sup>-7</sup>	2.93×10 <sup>-9</sup>	1.43×10 <sup>-7</sup>	1.59×10 <sup>-9</sup>
<b>Narrow space</b>	-	-	5.34×10 <sup>-9</sup>	None	8.49×10 <sup>-9</sup>	3.97×10 <sup>-10</sup>	1.91×10 <sup>-8</sup>	4.95×10 <sup>-10</sup>	2.61×10 <sup>-8</sup>	2.84×10 <sup>-9</sup>
Warehouse	8.30×10 <sup>-11</sup>	None	-	-	-	-	-	-	3.51×10 <sup>-9</sup>	None

## Documentation

- Guideline of design construction for ensuring safety from commercial air conditioners using lower flammability (A2L) refrigerants JRA GL-16 : 2016
- Requirements for ensuring safety against refrigerant leakage from commercial air conditioners using lower flammability (A2L) refrigerants JRA 4070 : 2016