

## Introduction

- [Subject system] Residential air-conditioners  
 [Refrigerants (A2L)] R32, R1234yf  
 [Risk assessment procedure]
1. Setup of an object product
  2. Analysis of risks
  3. Calculation of accident probability
  4. Planning of safety measures
  5. Establishment of the guideline

## Conclusion

- [Wall mounted type AC]  
 Satisfying the criteria of safety by review the ignition source and flammable spaces
- [Floor installed AC with single or multi type]  
 With ventilation, the lower flammability refrigerants can be safety used for them

## System

Table 1 Specification of a typical model

Type of residential AC	Wall mounted	Floor installed
Cooling capacity [kW]	4 kW	4 kW(each)
Refrigerant charge [kg]	1.0 kg	4.0 kg Max
Installation height	Wall 1.8m	Floor 0.0m

Fig.1 Images of subject system



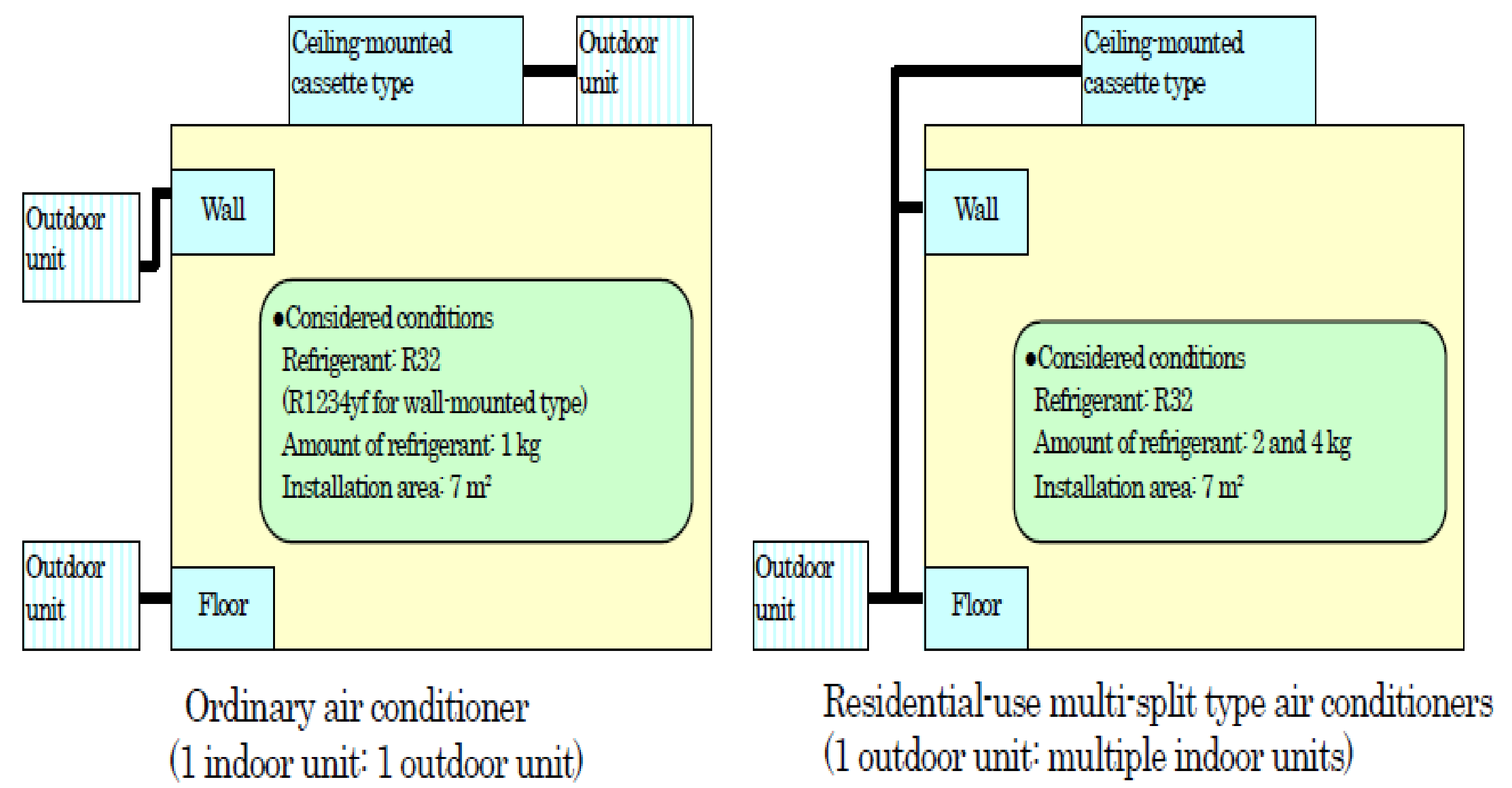
Wall-mounted AC



Floor installed AC

## Installation

Fig.2 Type of air-conditioners and installation

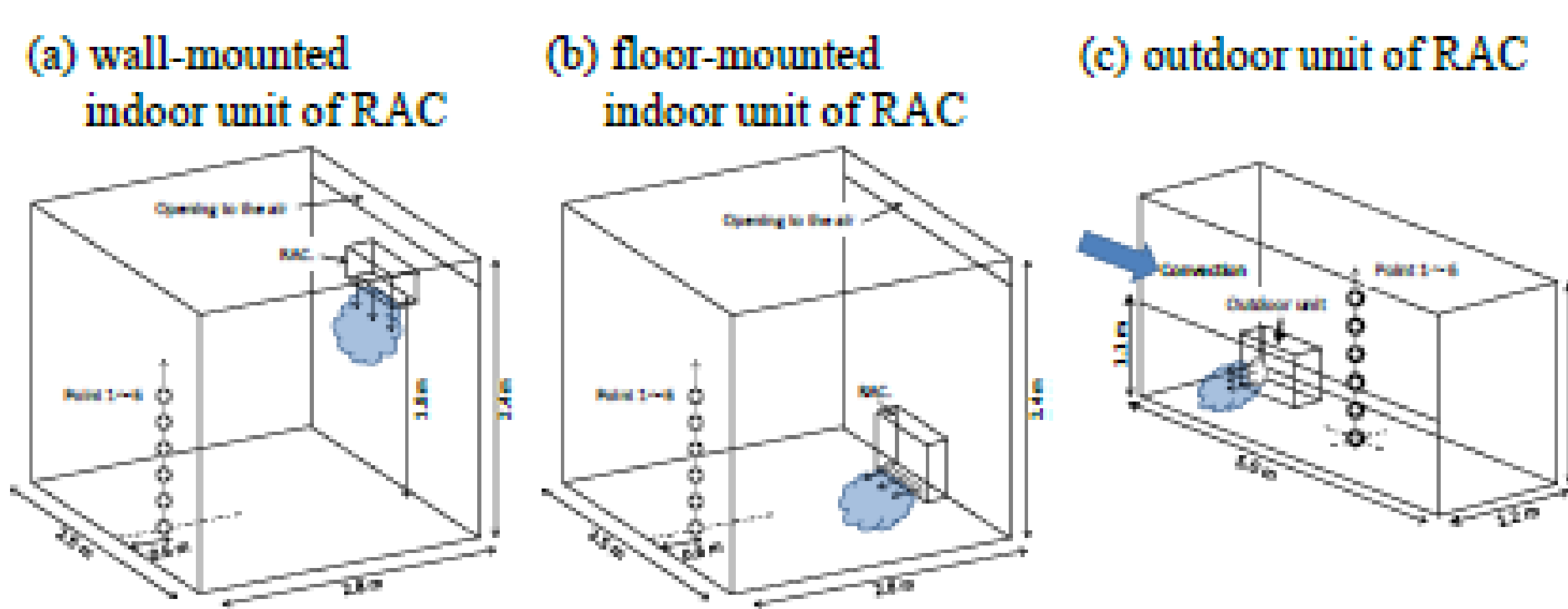


## Occurrence of refrigerant leakage

Table 2 Probability of the occurrence of refrigerant leakage [case/(unit year)]

Investigation	Leakage ratio	Leak rate
leakage	0.023%	0.25kg/min*

Fig.3 Simulation conditions



## Flammable volume

Table 3 Probability of flammable volume-time integration [m<sup>3</sup>·min]

	R32	R1234yf
1.1 Logistics	2.00 × 10 <sup>-4</sup>	2.20 × 10 <sup>-4</sup>
2.2 Installation	2.40 × 10 <sup>-3</sup>	2.50 × 10 <sup>-4</sup>
2.5 Mistakes	9.00 × 10 <sup>-3</sup>	1.30 × 10 <sup>-2</sup>
2.10 Refrigerant charge	9.97 × 10 <sup>1</sup>	3.70 × 10 <sup>2</sup>
3.1 Indoor unit operation	5.00 × 10 <sup>-4</sup>	5.50 × 10 <sup>-4</sup>
3.5 Indoor unit stop	2.40 × 10 <sup>-2</sup>	2.50 × 10 <sup>-2</sup>
4.1 Outdoor unit	9.00 × 10 <sup>-2</sup>	1.30 × 10 <sup>-1</sup>
5.1 Connecting pipe	9.97 × 10 <sup>2</sup>	3.70 × 10 <sup>3</sup>
7.8 Service/relief	9.07 × 10 <sup>-3</sup>	1.30 × 10 <sup>-2</sup>
8 Disposal	Using similar situations and values	

## Ignition source

## Probability of accidental fire

- [Open flame]
- Match, Oil lighter (open fire once ignited)
  - Burning appliance near floor
    - Electric radiant heater
    - Gas water heater
    - Gas cooking appliance
- [Spark]
- Metal spark (by forklift)
  - No ignition source by electrical part inside equipment (solenoid switch with 5kVA or under)

Table 4 Probability of accidental fire [1/(unit year)]

Refrigerant	Probability of accidental fire [1/(unit year)]			
	R32	R1234yf	R32 with countermeasures	
	Single type AC		Housing AC	
Category	Wall-mount	Wall-mount	Single type floor mount	Multi type floor mount
Logistics	4.1 X 10 <sup>-17</sup>	4.5 X 10 <sup>-17</sup>	3.6 X 10 <sup>-11</sup>	1.1 X 10 <sup>-9</sup>
Installation	2.7 X 10 <sup>-10</sup>	3.1 X 10 <sup>-10</sup>	4.0 X 10 <sup>-11</sup>	9.0 X 10 <sup>-9</sup>
Usage [indoor]	3.9 X 10 <sup>-15</sup>	4.3 X 10 <sup>-15</sup>	4.1 X 10 <sup>-10</sup>	4.7 X 10 <sup>-10</sup>
Usage [outdoor]	1.5 X 10 <sup>-10</sup>	2.1 X 10 <sup>-10</sup>	8.6 X 10 <sup>-11</sup>	1.1 X 10 <sup>-9</sup>
Service/Repair	3.2 X 10 <sup>-10</sup>	3.6 X 10 <sup>-10</sup>	2.6 X 10 <sup>-10</sup>	4.3 X 10 <sup>-9</sup>
Disposal	3.6 X 10 <sup>-11</sup>	5.3 X 10 <sup>-11</sup>	2.5 X 10 <sup>-11</sup>	4.1 X 10 <sup>-10</sup>

## Measures (Technical requirements for housing AC)

1. Technical requirement:
  - Agitation of indoor room air with refrigerant by unite fan
  - Caution of circuit breaker not to shutdown in all seasons
2. Review of condition
  - Refrigerant concentration at air outlet of floor installed AC
  - Clearance of door and slide door in Japanese house

## Documentation

1. Annual Progress Report for Risk Assessment of Mildly Flammable by JSRAE