

### Introduction

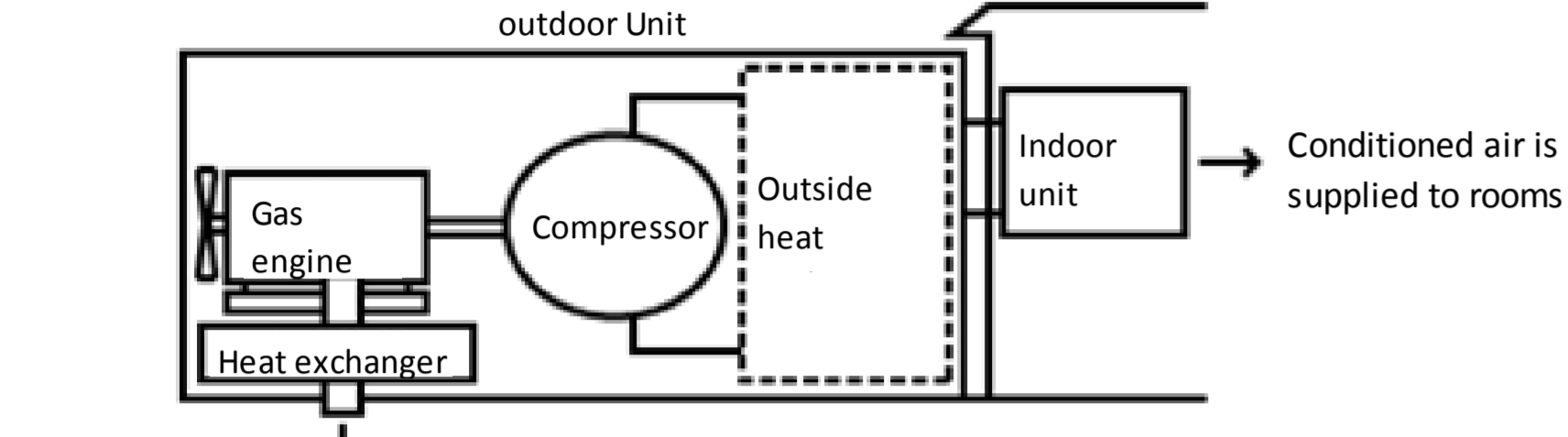
#### Philosophy

GHP is similar to electric air-conditioning systems (EHP), except it has a gas engine to drive compressors instead of electric motors.

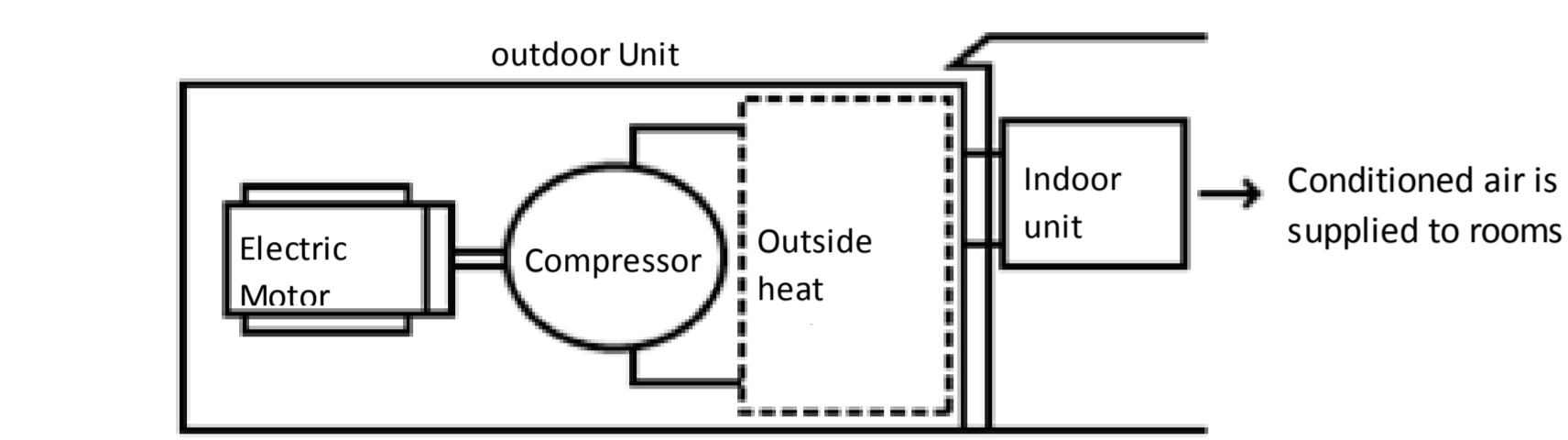
#### Procedure

- i) Evaluation of the risk assessment of EHP
- ii) Abstraction of items to be re-evaluated
- iii) Abstraction of regions in GHP to be evaluated
- iv) Implementation of risk assessment reflecting the results of ii) and iii) on the results of i)

Gas engine driven air-conditioning systems (GHP)



Electric air-conditioning systems (EHP)



### Conclusion

#### High Risk Cases and Guide Line for Safety

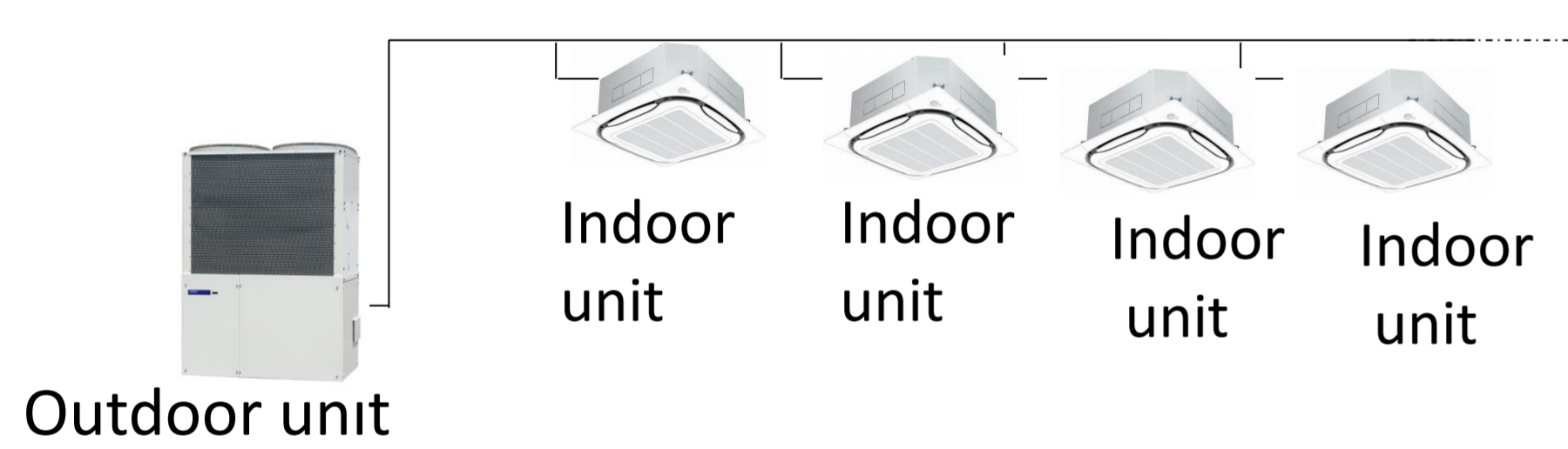
Guide line, GL-16 and JRA 4070 should be applied for GHP, because the evaluated risk was equal to the risk of EHP as the result of the risk assessment.

Risk assessment result of GHP charged R32

Installation Case (Charged refrigerant kg)	Life stage	[time/(unit/year)]											
		A. Transportation /Storage		B. Instalation		C. Usage(indoor) D. Usage(outdoor)		E. Repair/ Service		F. Disposal			
		<3.7X10 <sup>-8</sup>		<3.7X10 <sup>-9</sup> (indoor), 2.2X10 <sup>-8</sup> (outdoor)		<3.7X10 <sup>-8</sup>							
		Allowable probability	Measure		N	Y	N	Y	N	Y	N	Y	
Indoor Unit	1. Ceiling (26.3 kg)	Office <40.6m <sup>2</sup> 2.7m>	7.57X10 <sup>-16</sup>	-	1.90X10 <sup>-9</sup>	-	3.58X10 <sup>-12</sup>	-	1.70X10 <sup>-11</sup>	-	5.63X10 <sup>-13</sup>	-	
	2. Floor (52.8 kg)				1.90X10 <sup>-9</sup>	-	2.95X10 <sup>-7</sup>	3.47X10 <sup>-9</sup>	2.40X10 <sup>-9</sup>	-	6.57X10 <sup>-11</sup>	-	
	3. Ceiling (110 kg)				-	-	1.17X10 <sup>-6</sup>	=0	1.70X10 <sup>-11</sup>	-	-	-	
Outdoor Unit	4. Open space (110 kg)	-	1.74X10 <sup>-16</sup>	-	1.90X10 <sup>-9</sup>	-	3.41X10 <sup>-9</sup>	-	2.80X10 <sup>-10</sup>	-	4.62X10 <sup>-9</sup>	-	
	5. Each floored (110 kg)	<4.2m <sup>2</sup> 4m>			1.90X10 <sup>-9</sup>	-	3.78X10 <sup>-9</sup>	-	6.28X10 <sup>-10</sup>	-	9.38X10 <sup>-9</sup>	-	

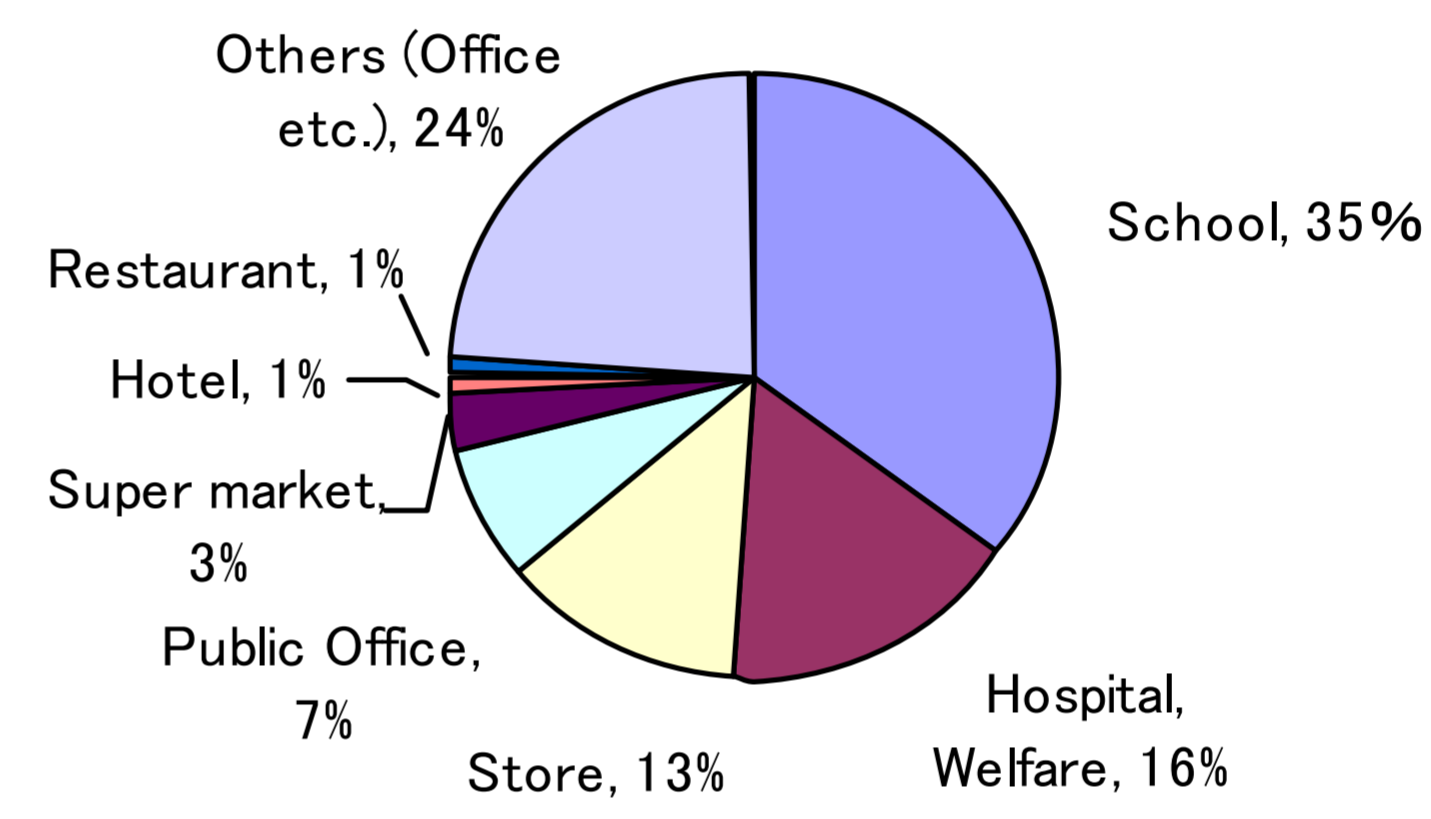
### System

Cooling capacity: 14.0 ~ 170kW  
Charge amount of refrigerant: 11.0 ~ 110.0kg  
Type: Variable refrigerant flow system for buildings (Indoor units are same as EHP)



### Installation

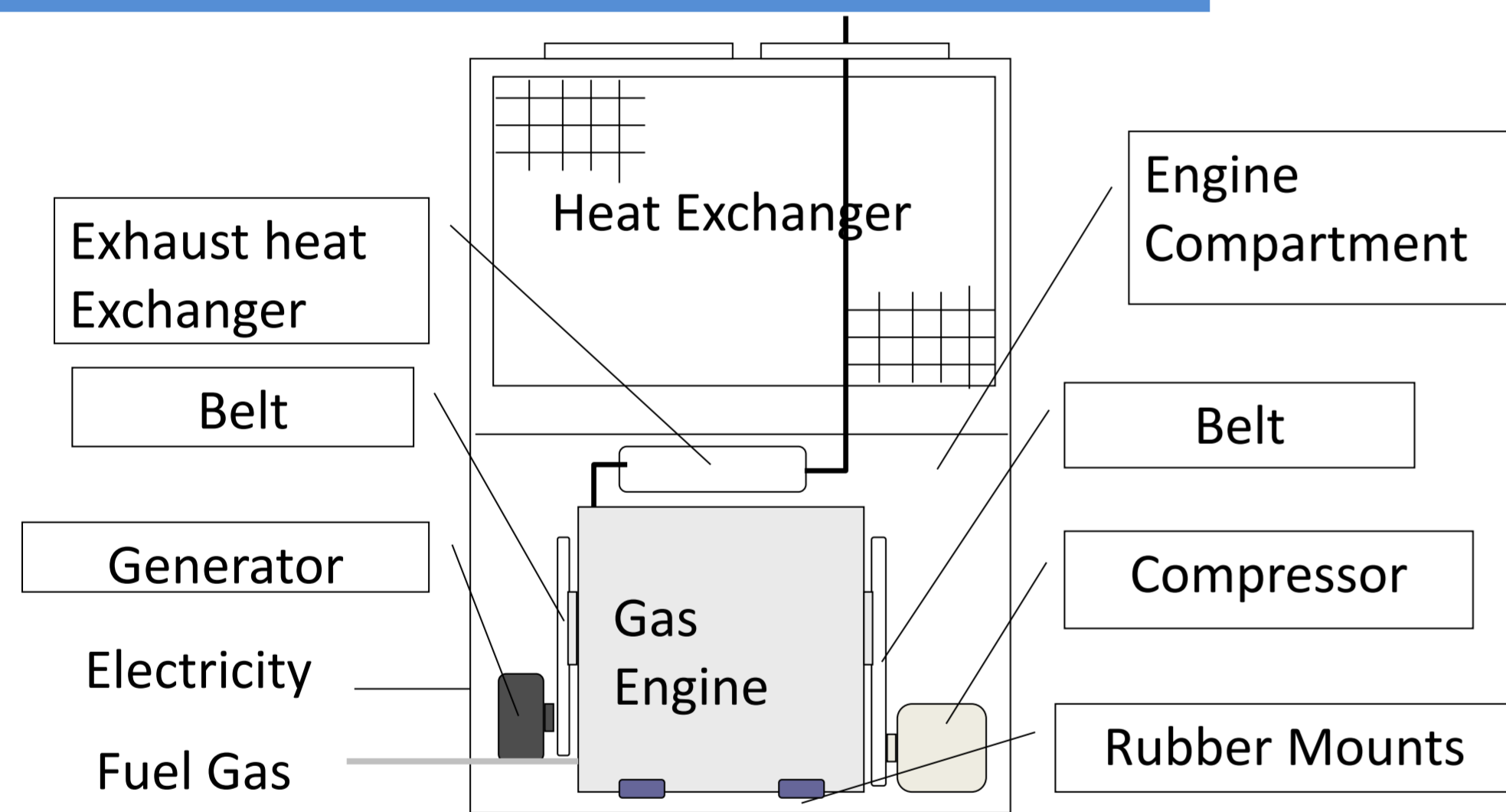
Total number : Approx. 450 thousands outdoor units in Japan  
User:



Industry Classified Capacity Ratio of GHP

### Focused Items of outdoor unit

#### Difference with EHP (outdoor unit)



Region	Main Components in GHP	Main Components in EHP	Refrigerant Leakage Risk	Ignition Risk
Ignition System	Ignition coil, Ignition plug	Not Applicable		No good
Compressor Drive	Belt, Engine, Electromagnetic clutch	Inverter, Motor		No good
Exhaust Path	Muffler, Exhaust heat exchanger	Not Applicable		No good
Fuel Gas System	Gas regulator, Shut off valve	Not Applicable		
Power Supply	Generator, Convertor	Not Applicable		
Generator Drive	Belt, Engine	Not Applicable		
Refrigerant Circuit	Open type compressor, Exhaust heat exchanger	Hermetic type compressor	No good	
Cooling Water Circuit	Water pump, Radiator	Not Applicable		
Housing	Sealed engine compartment, Air vent	Exposed		No good

#### Flammable volume-time integration in Engine Compartment (A)

- i) Refrigerant concentration was calculated by formula (a), because the Engine compartment is forcibly ventilated.
- ii) Refrigerant concentration was calculated under each conditions of Cooling/Heating mode, outside temperature and refrigerant leak rate (10kg/h or 75kg/h). See Figure 1 and 2.
- iii) Flammable volume-time integration in the engine compartment was calculated.

$$K = M(1 - e^{-QT/R}) / Q \dots (a)$$

K: Refrigerant concentration  
M: Refrigerant leakage rate (m<sup>3</sup>/h)  
Q: Ventilation flow of each outside temperatures (m<sup>3</sup>/h)  
R: Engine compartment volume (m<sup>3</sup>)  
T: Leakage duration (h)

Figure 1. Cooling Mode

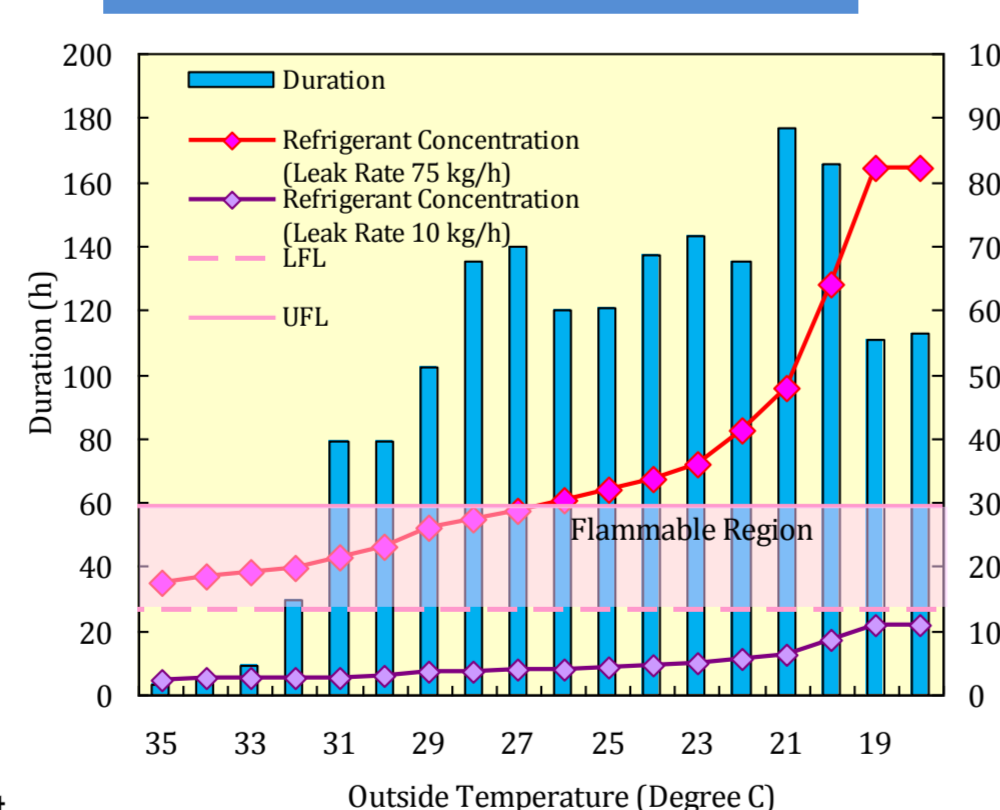
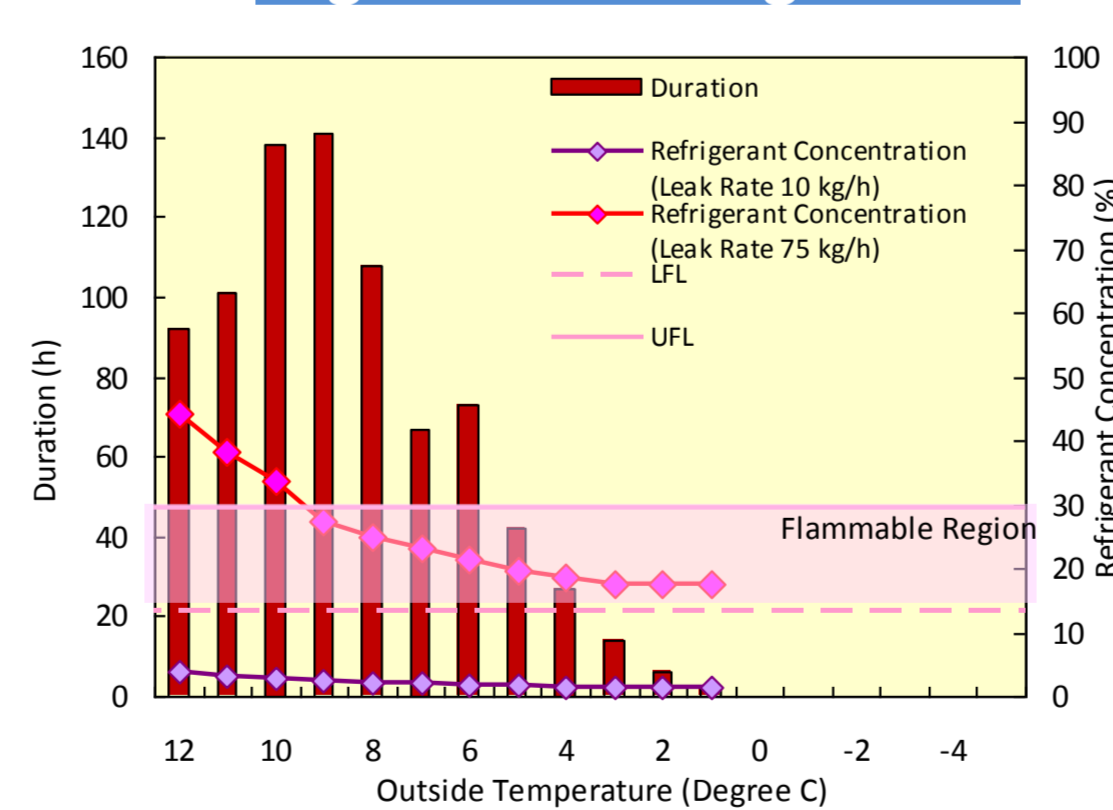


Figure 2. Heating Mode



Leak rate (kg/h)	1	10	75
Flammable volume-time in the engine compartment (m <sup>3</sup> -min)	0	0	3.82X10 <sup>1</sup>
Refrigerant leakage frequency (%/y)*	8.14X10 <sup>-3</sup>	1.78X10 <sup>-3</sup>	1.82X10 <sup>-4</sup>

\*Refrigerant leakage frequency : Calculated by the actual value in 2014, 1.01% / year

#### The probability of the presence of specific ignition source of GHP per unit time and volume (B)

X: Cannot be denied the possibility to be an ignition source  
- : No possibility to be an ignition source  
(not reach to the ignition energy nor ignition temperature)

Region	Possibility of spark or high temperature	Non-operational or Starting up		In operation	
		Normal	Abnormal	Normal	Abnormal
1. Ignition System	Leakage of spark to outside	-	X	-	X
2. Clutch	Spark by slipping	-	-	X	X
	Overheating by slipping	-	-	-	X
3. Exhaust path	Overheating by heat of exhaust gas	-	-	-	X
<b>Total</b>		<b>6.28X10<sup>-11</sup></b>		<b>1.49X10<sup>-6</sup></b>	

#### Ignition Risk

Installation	Ignition risk in operation	Criteria	Evaluation result
Open space	3.41X10 <sup>-9</sup>	Less than 2.20X10 <sup>-8</sup>	OK
Each floored	3.78X10 <sup>-9</sup>	Less than 2.20X10 <sup>-8</sup>	OK

### Documentation

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