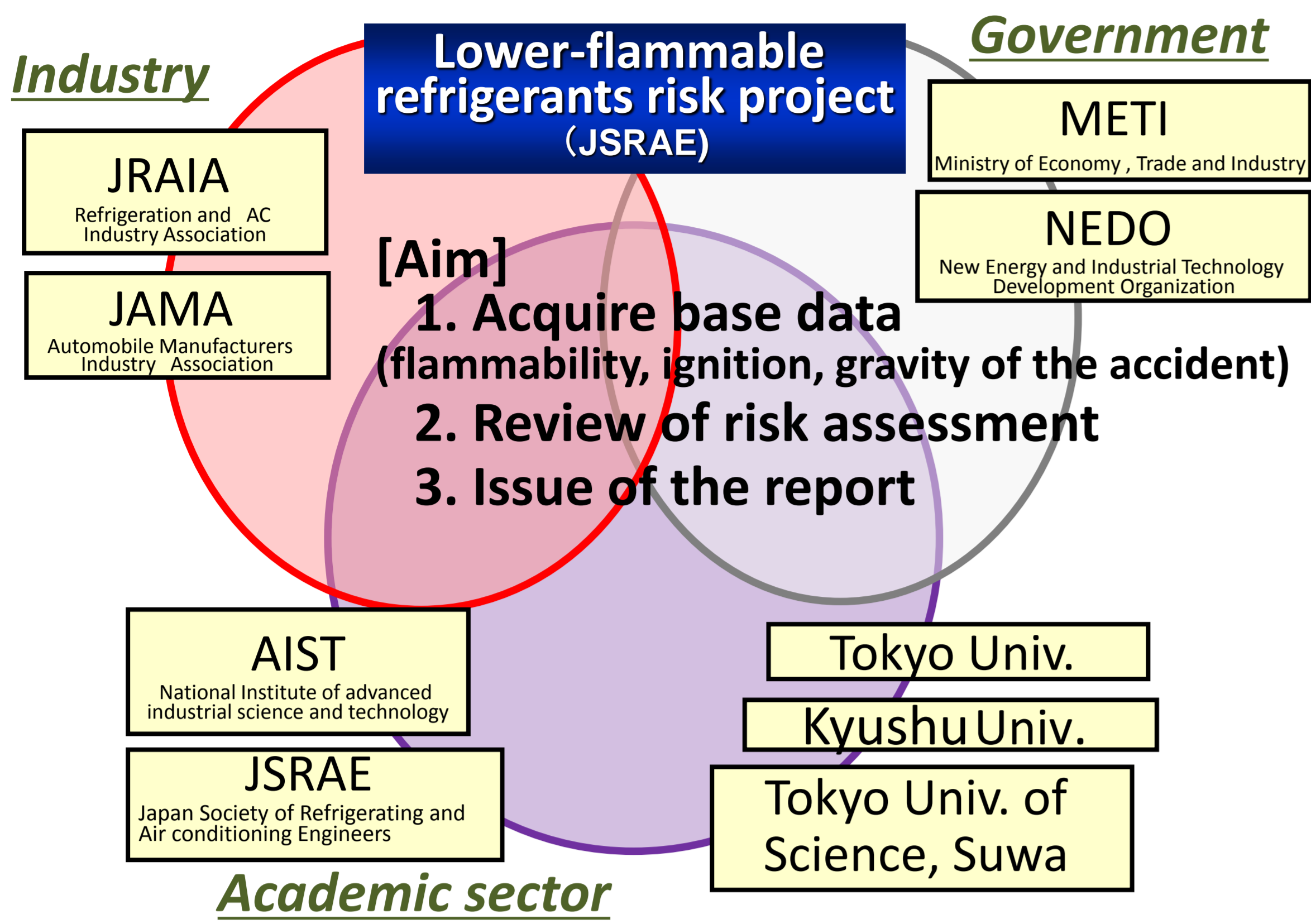


Organization for Risk Assessment

Cooperation among Industry, Government and Academy



JRAIA has been carrying out Risk Assessment from 2011 to 2016

Conclusion

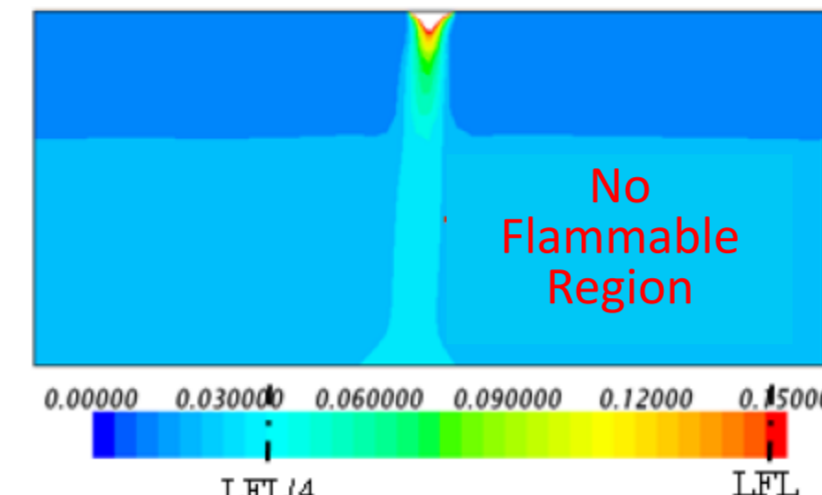
Normal case : This case is safe

1. The charge amount of refrigerant is small hardly to generate a flammable region.
2. Moderate ventilation can avoid a generation of a flammable region.

Usually, charge amount is small compared to LFL

Office	Restaurant	Smallest Karaoke Room
Room Size : 169m ² A/C Capacity : 30kW Charge amount : 19kg Charge of LFL : 140kg	Room Size : 14m ² A/C Capacity : 30kW Charge amount : 4kg Charge of LFL : 11kg	Room Size : 10m ² A/C Capacity : 4kW Charge amount : 1.2kg Charge of LFL : 8kg

Moderate ventilation can avoid the generation of Flammable region



This is a case when 88kg of refrigerant leaked to the room with moderate ventilation where LFL limit is 33kg.

Risk case : This case requires a leak detector and some safety measure such as air-circulation, ventilation or shut-off valve.

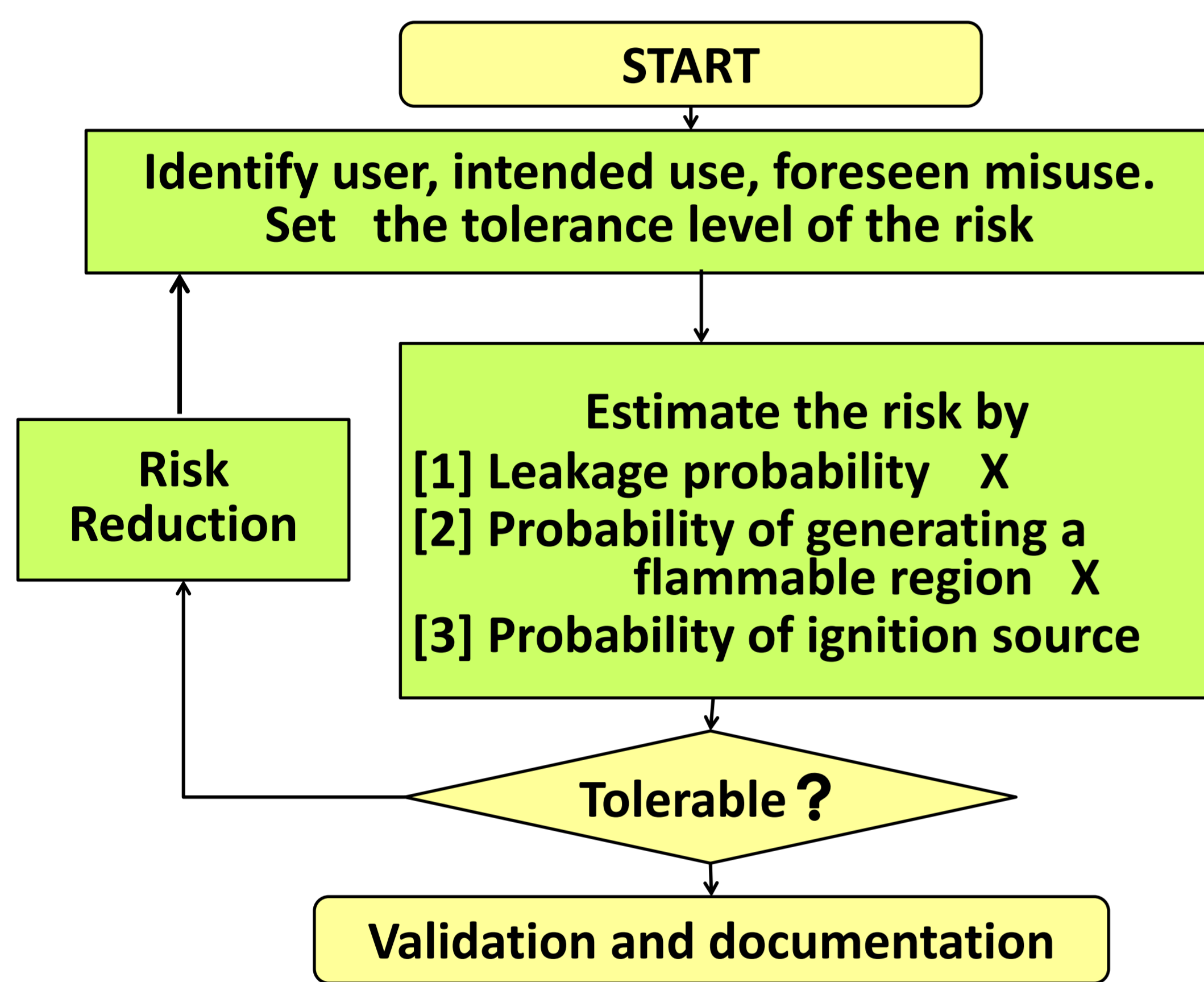
1. A case where the leaked refrigerant can not be circulated, such as a floor mounted unit etc.
2. A case where the charge amount of refrigerant is large compared for the room size enough to generate a flammable region without moderate ventilation.

Dangerous case : It should be avoided.

1. Most dangerous is the case when the leaked refrigerant would be ignited after it is filled in the room with stoichiometric concentration.

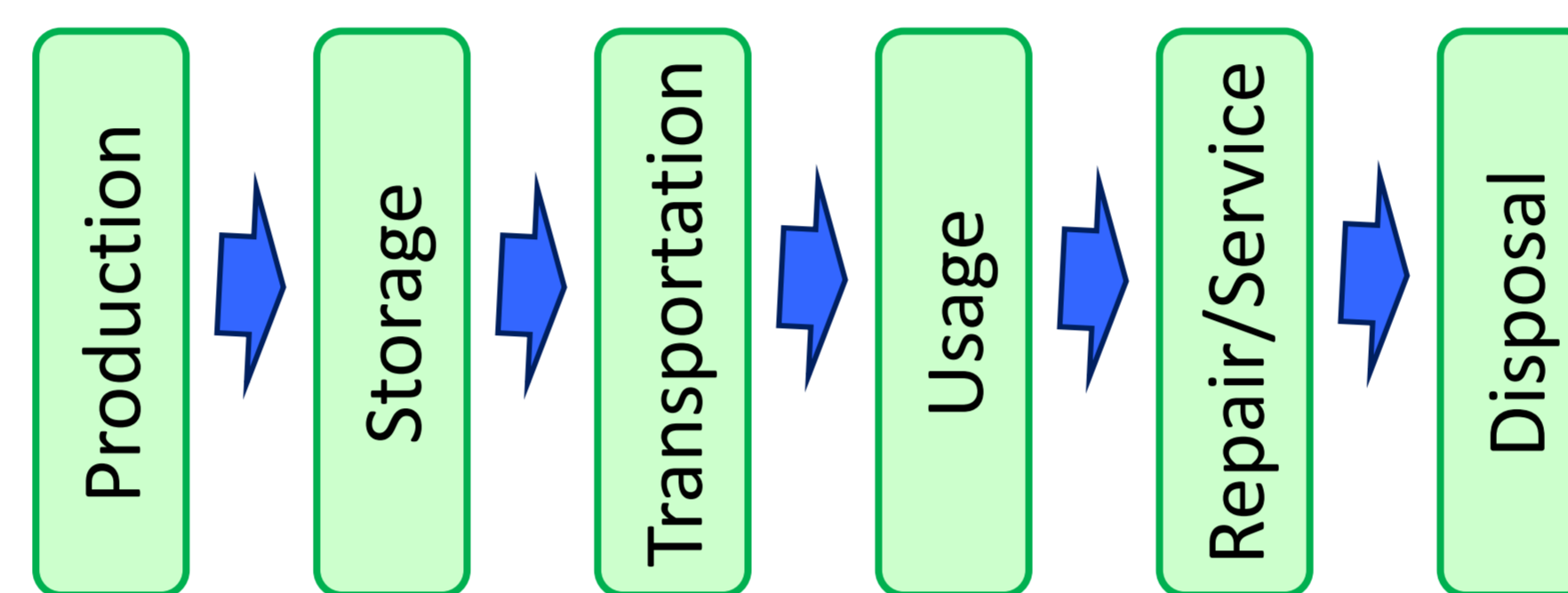
Basic Procedure

Based on ISO/IEC guide 51



Set life cycle and tolerable level

Life cycle range for assessment



Set Tolerable Probability for each system

Product/System	No. of units in market	Tolerable value in use	Tolerable value except for in use
Residential A/C	1.0 × 10 ⁸	1.0 × 10 ⁻¹⁰	1.0 × 10 ⁻⁹
Commercial A/C	7.8 × 10 ⁶	1.3 × 10 ⁻⁹	1.3 × 10 ⁻⁸
VRF	1.0 × 10 ⁷	1.0 × 10 ⁻⁹	1.0 × 10 ⁻⁸
Chiller	1.34 × 10 ⁵	7.5 × 10 ⁻⁷	7.5 × 10 ⁻⁷

Set Tolerable Level in Risk Matrix for Residential AC

Probability of occurrence	Usually 10 ⁻⁵ ~	Frequently 10 ⁻⁶ ~	Sometime 10 ⁻⁷ ~	Rare 10 ⁻⁸ ~	Usually not 10 ⁻⁹ ~	Near Zero ~ 10 ⁻¹⁰	Severity of Harm				
							No	Minor	Light	Major	Lethal
							Not Acceptable				
							Acceptable with Condition				
							Acceptable				
							Tolerable				

JRAIA decided the tolerable level is less than one accident in one hundred years. We suppose a ignition would always cause lethal damage since we could not classify the severity of harm at present. It means JRAIA set the tolerable level sever at present.

Estimate the Risk : calculate by the formula " Ignition Probability= [1] × [2] × [3] "

[1] Estimate of the rapid leakage probability

- Assumed a rapid leak rate and the probability of leak for indoor units based on market data and IEC60335-2-40

[2] Estimate of the probability of generating a flammable region

- Assumed a normal condition and a risk case: considering charge amount of refrigerant, room size, ventilation, floor mounted type etc.
- Probability of existence of flammable region : calculated by the right side formula. Generated flammable volume-time integration is determined by CFD simulation.

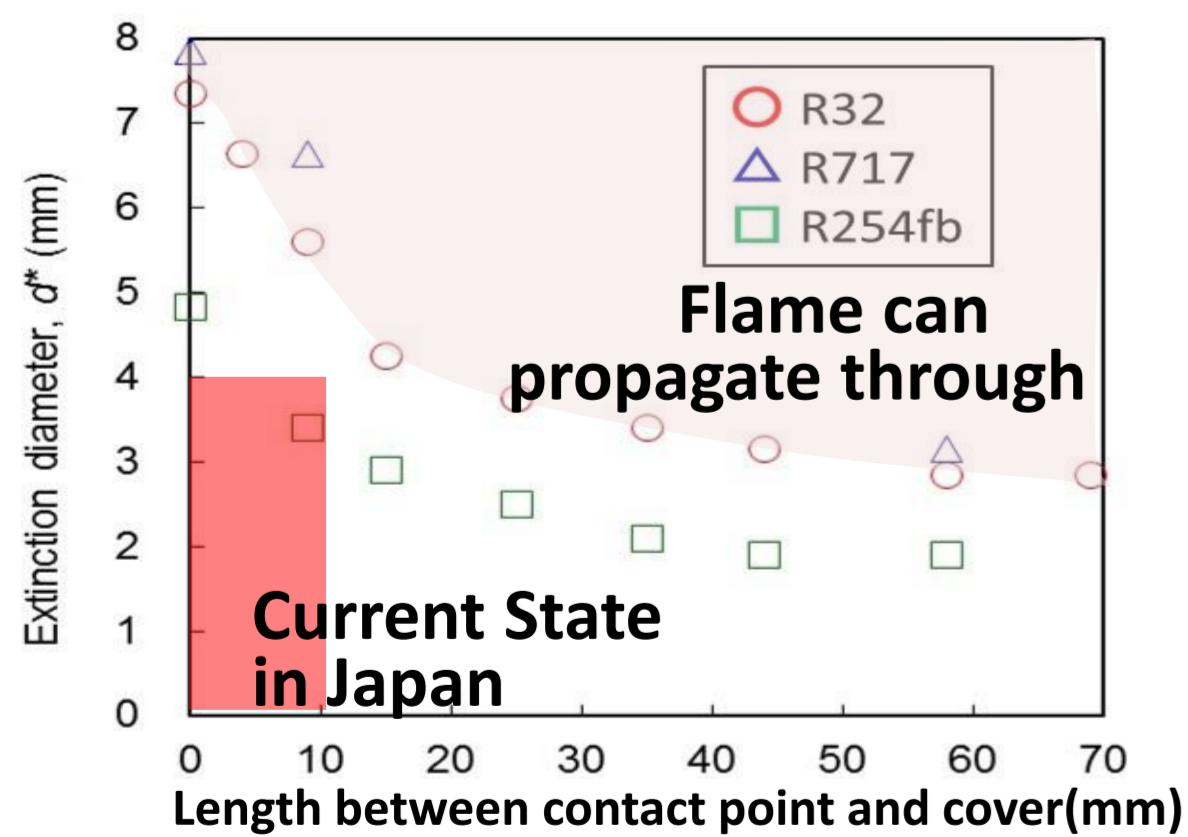
[3] Probability of the ignition source

- Probability of ignition sources: estimated from statistic data of gas fire accidents.
- Evaluation of ignition sources : NEDO project carried out the variety of ignition tests and researches as bellow;

AC type	Residential	Package	VRF	Chiller
Rapid Leak Rate	15kg/h	10kg/h	10kg/h	burst 75kg/h
Probability of leak	0.023%	0.0015%	0.0005%	burst 0.0010%

$$\text{Probability of occurrence of flammable region} = \frac{\text{Generated flammable volume-time integration}}{\text{Space-volume} \times \text{Total time}}$$

Research of Contactor



Electro Contactor can't be ignition source for R32

Ignition Test by Stove



Flame propagation didn't occur by various type of stoves

Hair Dryer Ignition Test

Refrigerant	R290	R152a	R254fb	R32
Flammability Class	3	2	2L	
S _{u0,max} , cm·s ⁻¹	39	24	9.5	6.7
Result, # of ignition/ # of trial	3/3	1/1	0/40	0/40

2L gas were not ignited

Ignition Test by Lighter



Gas lighter can't ignite 2L gas

Documentation

1. Safety Guideline (GL-20) related to High Pressure Gas Safety Act

Basic policy of the safety guideline is to avoid flammable region. Therefore, it strictly limits the charge amount of refrigerant to less than or equal to 1/4 of LFL. When more than it, a detector-alarm and some safety measures are required.

2. Guidelines or manuals for each applications

JRAIA is providing precise guidelines or manuals for each application.

3. JSRAE published the final report for risk assessment

The final report for the risk assessment will be published near soon by JSRAE.

