Implementation of Alternative Refrigerants in Japan

- Safety assessment and legislation for the use of A2L refrigerants -

Tetsuji Okada

The Japan Refrigeration and Air Conditioning Industry Association (JRAIA)

18 July, 2016
Vienna, Austria

JRAIA 一般社団法人 日本冷凍空調工業会
The Japan Refrigeration and Air Conditioning Industry Association

Who is JRAIA?

JRAIA 一般社団法人 日本冷凍空調工業会
The Japan Refrigeration and Air Conditioning Industry Association

The Japan Refrigeration and Air conditioning Industry Association (JRAIA)

- Established in 1949.
- 164 member companies including the associate members.
  (as of 1st of June 2016)
- The business fields of the member companies are :
  - Air conditioning (residential, commercial, automotive)
  - Refrigeration (commercial, industrial, transport)
  - Ventilation
  - Chiller
  - Heat pump system (HP water heaters)
  - Refrigerants
  - Parts

0. Contents

1. Background
2. Requirements for the alternative refrigerants
3. Key Activities in Japan
4. Legislation in Japan
5. Consideration points for the risk assessment
6. Conclusion

WHY A2L refrigerants NOW?

- In order to tackle the mitigation of global warming, there is a call for alternative refrigerant with lower GWP than currently used in non-A5 countries.

- However, most of the refrigerants proposed as the alternatives are classified as lower flammability class (A2L).

- In Japan, the government, academic sectors and industry swiftly cooperated together for the safe use of A2L refrigerants and greater contribution to the mitigation of global warming as soon as possible.

- Today, we would like to present the current status in Japan.

2. Requirements for Alternative Refrigerants

JRAIA 一般社団法人 日本冷凍空調工業会 The Japan Refrigeration and Air Conditioning Industry Association

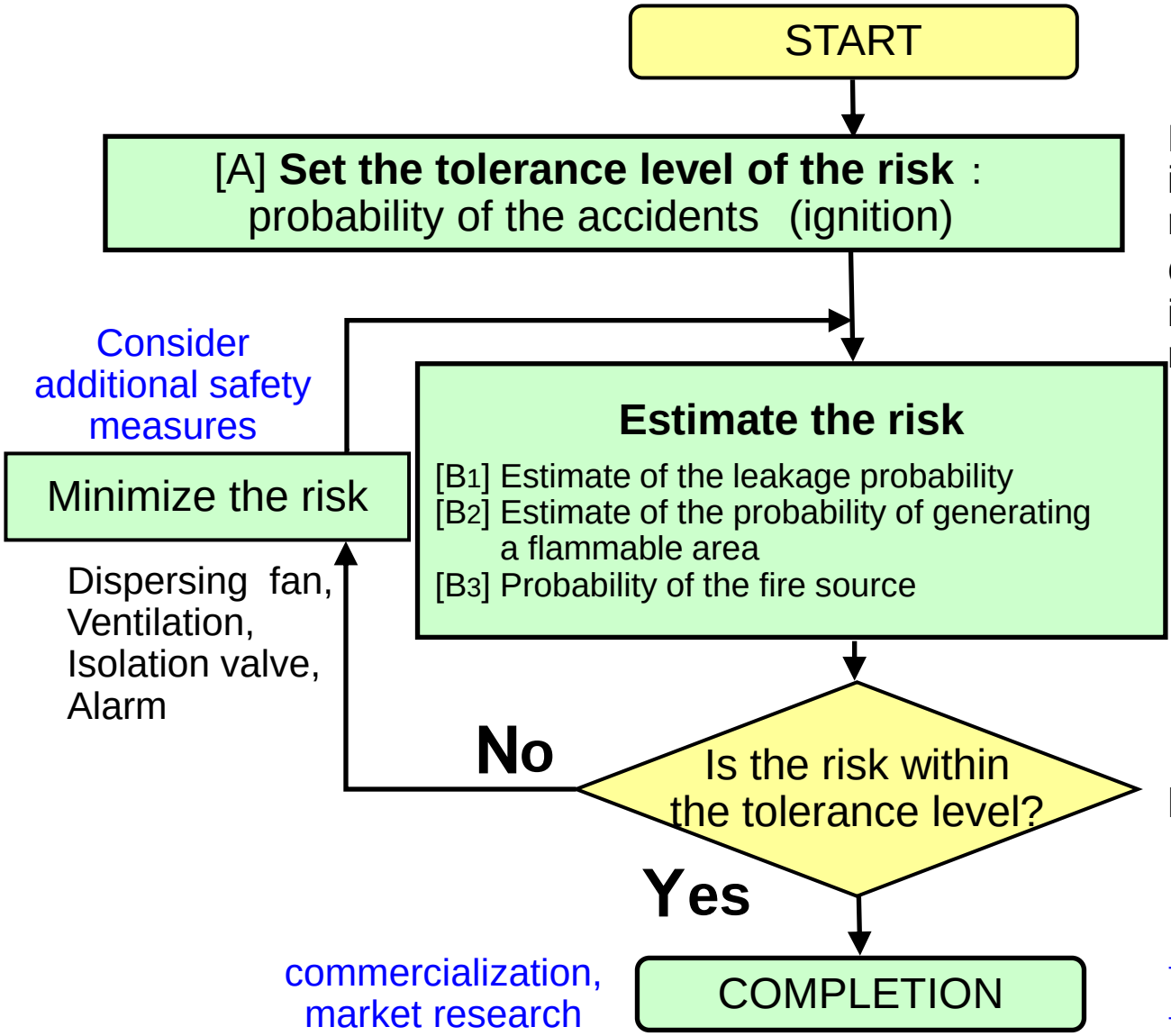
Actions to phase down HFCs have been started sector by sector in Japan by considering not only environment performance but also safety, energy efficiency and economic feasibility.

S+3E

Safety (precondition)	・Low Toxicity ・Low Risk of Flammability
Environment Performance	・Ozone Depletion Potential =0 ・Low Global Warming Potential
Energy Efficiency	・Superior for LCCP* value ・Similar performance at high load cooling
Economic Feasibility	・Reasonable Cost ・Acceptable level in Developing Countries

LCCP*：Life Cycle Climate Performance

3. Key Activities in Japan: Basic Procedure for RA



Extract the flammability risks including source of the fire and refrigerants leakage

Clarify the difference of intended-use and predictable miss-usage

- Set the product range for the risk assessment
- Selection of the risk assessment procedure and the stage of the life-cycle

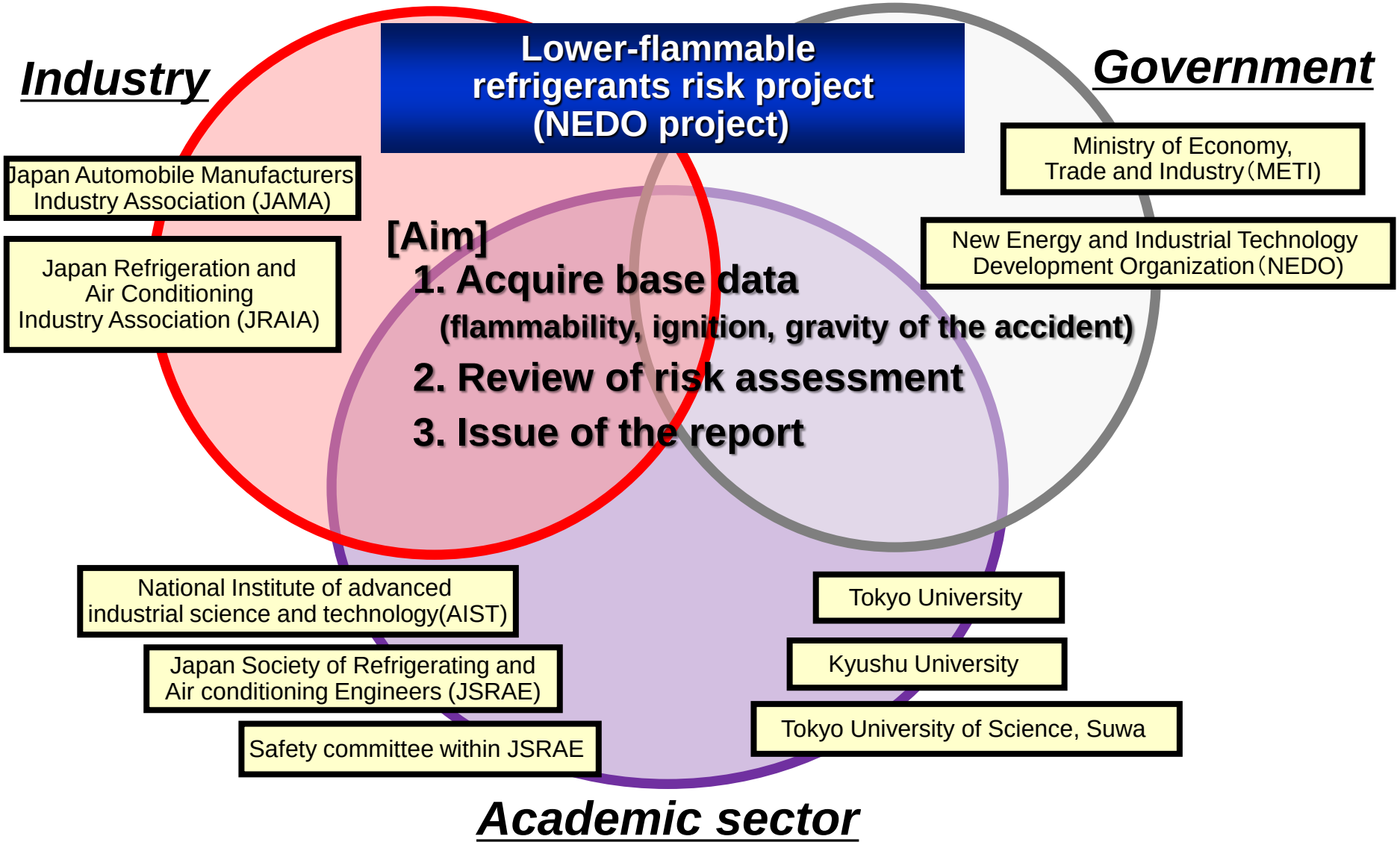
Decisive quality criteria:

[A] > [B1] × [B2] × [B3]

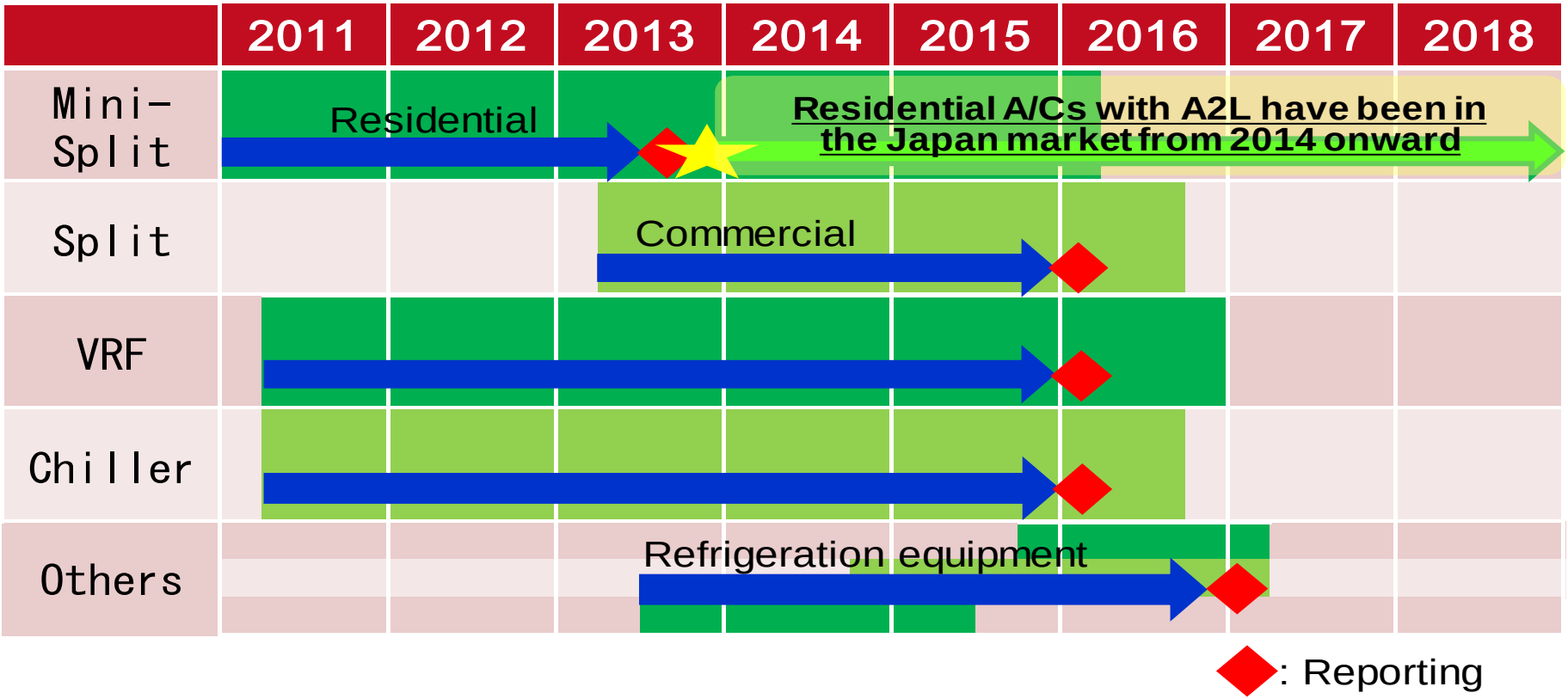
→ guidelines・manuals

→ standard , legislation

3. Key Activities in Japan：Key Partners



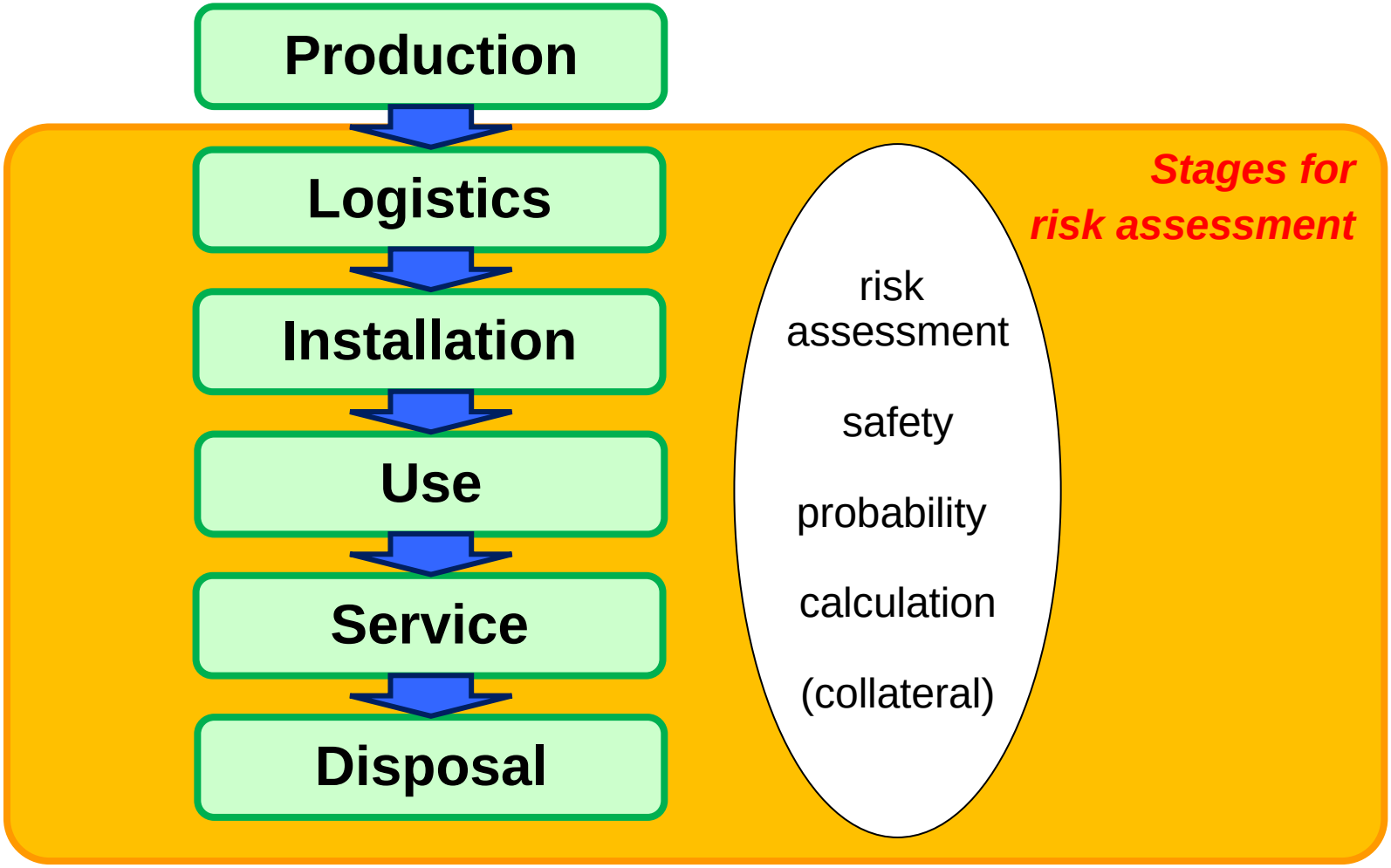
3. Key Activities in Japan：Timescale



- Risk Assessment for more complicated large AC products and refrigeration equipment will be concluded by the end of 2016.
- Implementation of safety measures for these products will follow soon.

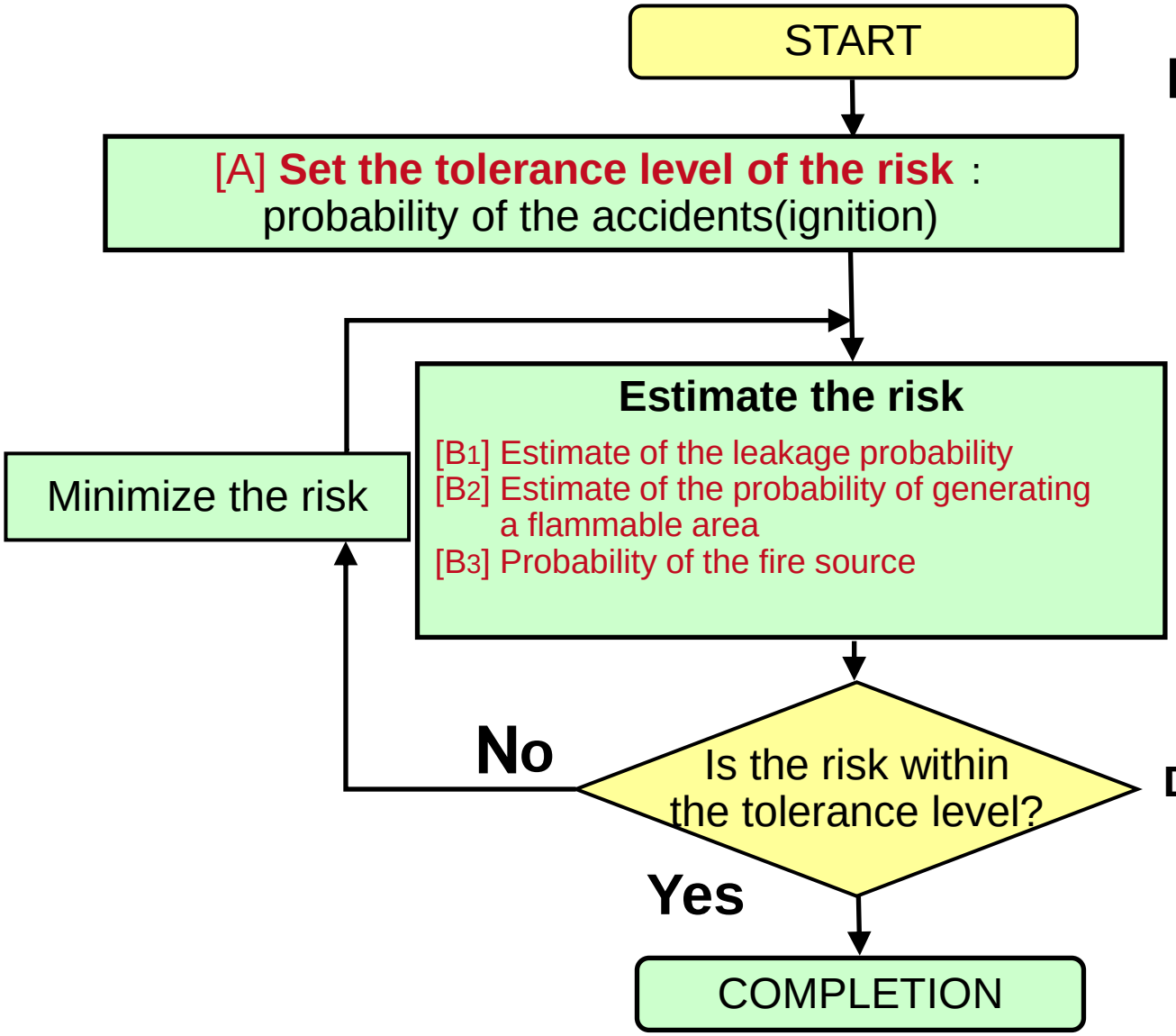
3. Key Activities in Japan：Base case [Mini-split]

Select the life-cycle-stage for risk assessment



3. Key Activities in Japan：Base case [Mini-split]

JRAIA 一般社団法人 日本冷凍空調工業会
The Japan Refrigeration and Air Conditioning Industry Association



Basic procedure

Decisive quality criteria:

[A] > [B1] × [B2] × [B3]

[A] Set the tolerance level of the risks
：probability of the serious accidents

- **Acceptable number of fatal accident; Once (P) in the estimated period among the number of product units within each life-stage period**

- **Fatal accident means “ignition”.**

- **Number of product units (N) within each life-stage：**
  During use： 10 million units x 10 years (product life)
  During storage / transport / maintenance / disposal：
  10 million units x1year

- **Estimated time period (T)：**
  100 years ：mini-split , VRF (estimate by the use without maintenance)

- **Tolerance level of the risk：(= P / (N x T))**
  During use： 10^{-10} units /year
  During storage / transport / maintenance / disposal ：
  10^{-9} units /year

4. Key Activities in Japan：Base case [Mini-split]

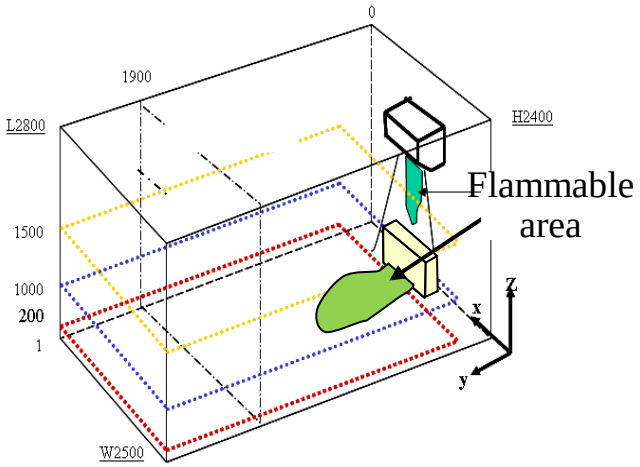
JRAIA 一般社団法人 日本冷凍空調工業会 The Japan Refrigeration and Air Conditioning Industry Association

[B1] Estimate of the leakage probability

- **Rapid leakage probability in Japan market : 0.023%**
  Calculation of leakage probability for HVAC servicing companies (JRAIA member) is averaged by market shares of each company.

[B2] Estimate of the probability of generating a flammable area

- **Leak rate and amount from the equipment :**
  Entire charged refrigerants in 4 min.
  (refer to IEC60335-2-40)
- **Assumed room size and equipment :**
  Set severe condition with small room
  - Leak space： floor area 7m² x height 2.4m
  - Wall mounted AC 1.8m above the floor
- **Formula :**



$$\text{Probability of generating a flammable area} = \frac{\text{Generated volume of flammable area x Duration}}{\text{Space-volume x Total time}}$$

[B3] Probability of the ignition source

- **Evaluation of the ignition sources**

  Test result : Refrigerants did not ignite by tobacco or gas lighters, but ignited with open mild flame by candles and matches.

- **Probability of the ignition source**

  Probability was estimated from statistic data of gas fire accidents, the number of residences and residential floor areas in Japan.

Test result of the Risk Assessment

Safety criteria (Use) Ignition probability ≒ 10^{-10} , (Others) Ignition probability ≒ 10^{-9}

Life stage	Ignition probability (R32 (A2L))
Logistic	4.1×10^{-17}
Installation	2.7×10^{-10}
Use (Indoor)	3.9×10^{-15}
Use (Outdoor)	1.5×10^{-10}
Service	3.2×10^{-10}
Disposal	3.6×10^{-11}

- After safety criteria was determined, risk assessment over the total life cycle was conducted.
- If the risk level exceeds the safety criteria, additional safety measures must be taken to satisfy the criteria. They are to be applied to the safety manual and guideline. Required practices should follow depending on the necessity.

In this risk assessment, wall mounted ACs were proven to be within the tolerance level for ignition possibility, even without additional safety measures

The details of activities and the progress reports are available in the following website:
http://www.jsrae.or.jp/jsrae/committee/binensei/risk_eng.html **Source: JSRAE**

4. Legislation in Japan：Measures and Act

JRAIA 一般社団法人 日本冷凍空調工業会
The Japan Refrigeration and Air Conditioning Industry Association

The equipment over the tolerance level of risk (Decisive quality criteria) must adapt safety measures below ;

ⅰ Design to prevent pooling : Dispersing fan, Ventilation, Isolation valve to minimize flammable area

ⅱ Set detector / alarm

"High pressure gas safety act" covers flammability as well as toxicity. Currently the revision of classification in this act is under consideration by adapting the safety measures stated above. In addition to international standards such as ISO5149 and IEC60335-2-40, Japan is considering to add the safety obligation set for each equipment to prevent the fire during gas leak by adapting two JRA standards below ;

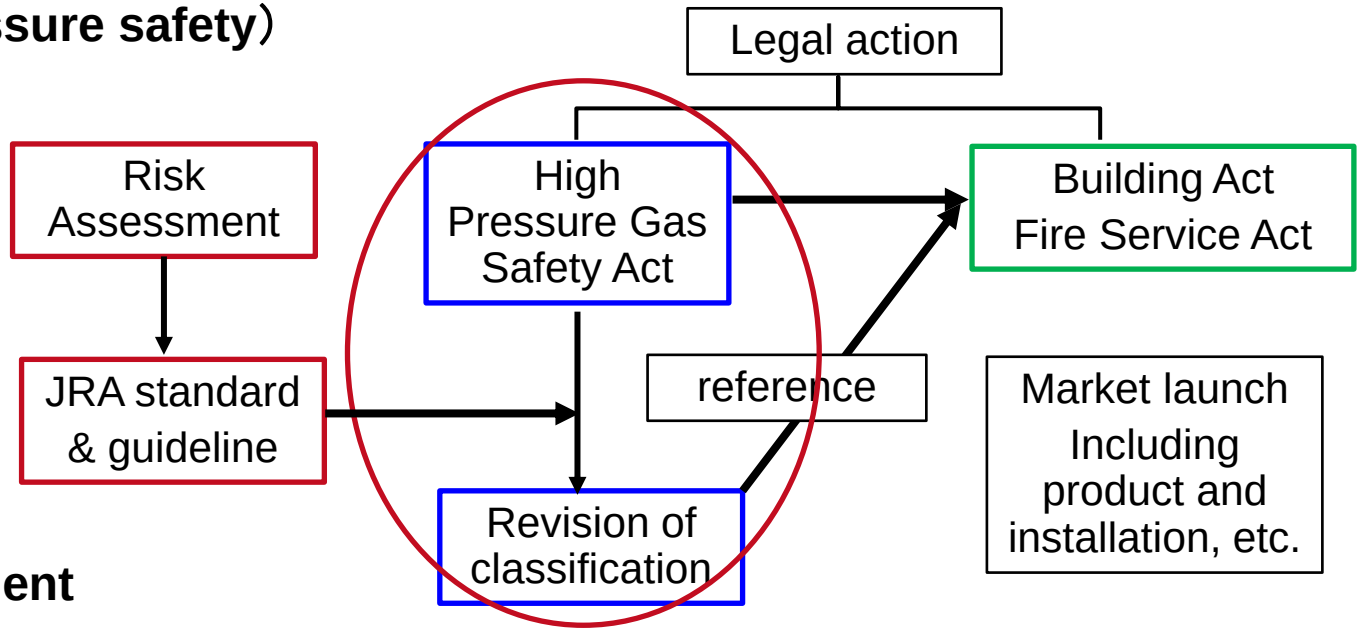
- **JRA GL-20 : JRAIA guideline**
- **JRA 4068 : JRAIA standard**

4. Legislation in Japan ：Revision of Classification

1. What is “High Pressure Gas Safety Act” ?

This act is the regulation for high pressure gas, but covers toxicity and flammability of the refrigerants, and applies to HVAC equipment of the size above certain refrigerant volume.

2. Step toward revision of classification for A2L refrigerants (legislations to assure safety）



3. Review System

1) Risk Assessment

2) Revision of classification

⇒ collaboration of government , academic sectors and industry

JRAIA 一般社団法人 日本冷凍空調工業会 The Japan Refrigeration and Air Conditioning Industry Association

Global Legislation/ Act for flammable refrigerants

(mainly for the refrigerants with lower flammability)

	U.S.	Europe	Japan
Legislation/ Act	Clean Air Act SNAP	F−Gas Regulation, Act	Act on Rational Use and Proper Management of Fluorocarbons **High pressure gas safety act**
National legislation	**Building Code** IMC, UMC, etc.	**Building Code**	**High pressure gas safety act**
International standards	ISO817（refrigerant classification）		ISO5149（safety）
Standard / regulations (define ref types)	ASHRAE34	Relevant standards based on ISO	**High pressure gas safety act**
Standard / regulations (safety)	ASHRAE15 UL60335-2-40 UL484, etc.	EN378 EN60335-2-40	**High pressure gas safety act** JIS C9335-2-40 JRA standards, etc.

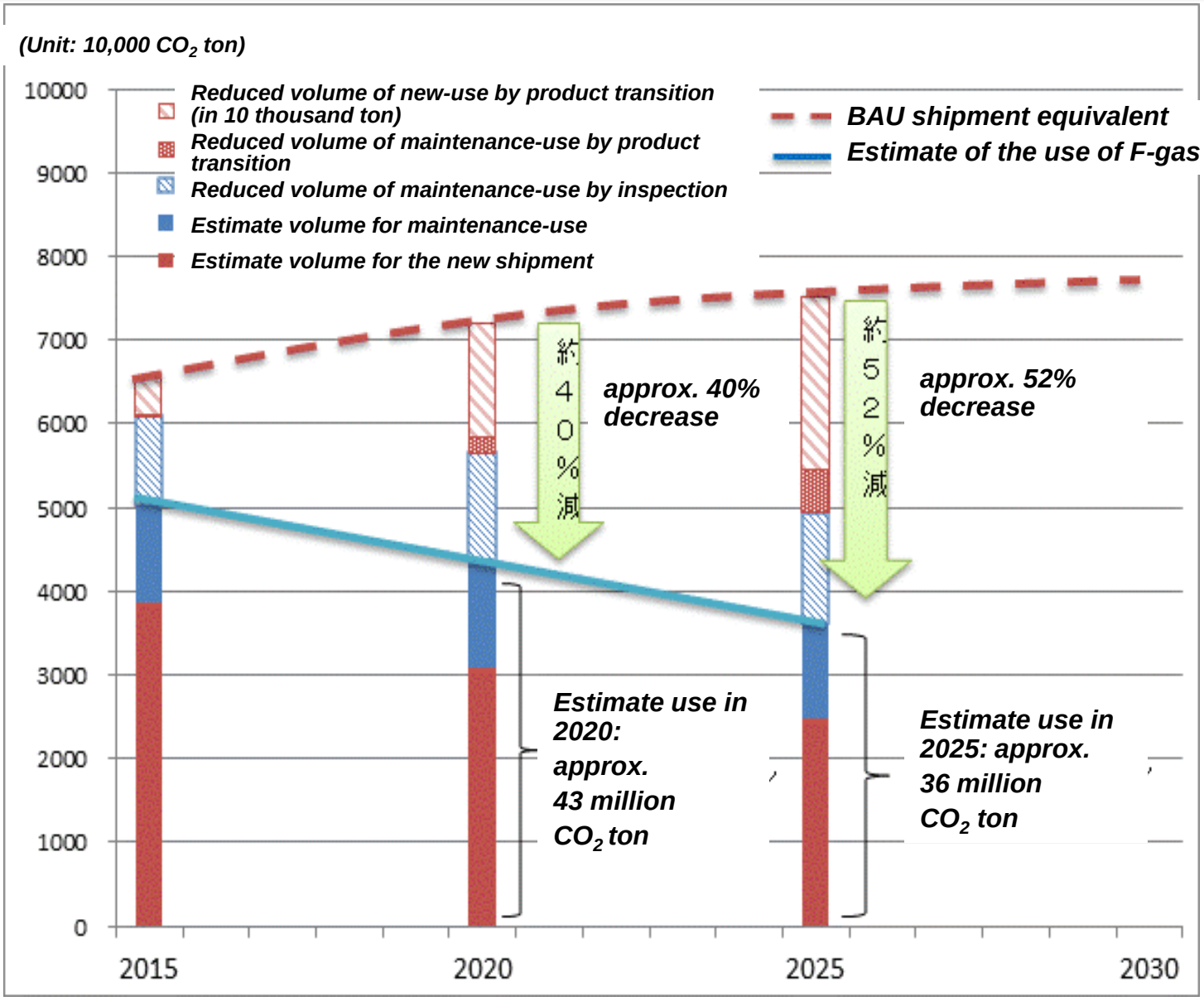
4. Legislation in Japan ：Target GWPs

JRAIA 一般社団法人 日本冷凍空調工業会 The Japan Refrigeration and Air Conditioning Industry Association

Act on Rational Use and Proper Management of Fluorocarbons sets target GWP and its schedule (plan) for each designated product

Designated Product	Target GWP (Weighted Average GWP)	Target year
Room air conditioning (Mini-Split)	750	2018
Commercial air conditioning (Split)	750	2020
Mobile air conditioning	150	2023
Condensing unit and refrigerating unit	1500	2025
Cold storage warehouses	100	2019
Urethane foam	100	2020
Dust blowers	10	2019

4. Legislation in Japan : Phasedown



5. Consideration Points : for Other Countries

JRAIA 一般社団法人 日本冷凍空調工業会 The Japan Refrigeration and Air Conditioning Industry Association

In case of other countries to adapt similar risk assessment, the factors below should be taken into account;

[A] Set the tolerance level matching each country:

⇒ the minimum tolerance level is stated as 10^{-8} in ISO/IEC guide 51
In Japan, strict tolerance level was adopted considering the probability of serious accident

[B1] Set leakage probability matching each country:

⇒Skill level of installers and product qualities may have the affect on refrigerant leaks.

[B2] Set the estimate of the probability of occurrence of flammable area matching each country:

⇒ In HAT (High Ambient Temperature) area, due to the equipment size (= refrigerants volume) to match the load, the risk may be higher

[B3] Set probability of the fire source matching each country:

⇒ Probability should be estimated based on the research data of gas fire accidents, number of residences, and residential floor area data of each country.

5. Consideration Points : A2L and A3

Note that refrigerants' ignition probability changes by its flammability.

When compared with **A2L**, **A3** has extremely high ignition probability at the preliminary discussion. JRAIA starts the risk assessment for A3 refrigerants.

	Ignition probability	
Life Stage	**R32 (A2L)**	**(ref. Propane (A3))**
Logistic	4.1×10^{-17}	$1.9 \times 10^{-8} \sim 5.0 \times 10^{-6}$
Installation	2.7×10^{-10}	$1.5 \times 10^{-5} \sim 1.7 \times 10^{-5}$
Use (Indoor)	3.9×10^{-15}	$5.9 \times 10^{-9} \sim 1.1 \times 10^{-4}$
Use (Outdoor)	1.5×10^{-10}	$9.7 \times 10^{-13} \sim 1.9 \times 10^{-8}$
Service	3.2×10^{-10}	$9.3 \times 10^{-6} \sim 1.7 \times 10^{-5}$
Disposal	3.6×10^{-11}	$1.8 \times 10^{-5} \sim 1.3 \times 10^{-4}$

6. Conclusion

- **In Japan, the conversion to A2L refrigerants started in the small sized ACs, with careful examination for its safety (**sold over seven million units in 2015**).**

- **The selection of alternative refrigerants must be made carefully by considering「S＋3E (Safety+ Environment performance, Energy efficiency, Economic feasibility)」**

- **Countries that are in the process of selecting alternative refrigerants should assess the risks of the candidates. We believe that the result done by Japan can help develop the way for the safe use of alternatives.**

- **Guideline, manuals and legislations in each country must be placed to take safety measures matching the risk levels to prevent accident and to encourage the use of A2L refrigerants.**

Thank you for your kind attention.

More Information！ ！

JRAIA 一般社団法人 日本冷凍空調工業会
The Japan Refrigeration and Air Conditioning Industry Association

http://www.jsrae.or.jp/jsrae/committee/binensei/risk_eng.html

公益社団法人 日本冷凍空調学会
Japan Society of Refrigerating and AirConditioning Engineers

Japanese
JSRAE Web Site Search
Updated on October 1, 2013

HOME
About JSRAE
Refrigeration Engineer
Awards
Academic Journal"REITO"
Research papers
Publications
JSRAE Annual Conference
Meeting Calendar
Study
JSRAE Books
Order Form
JSRAE Member Site
login page(in Japanese).

Research committee for the risk assessment of mildly flammable refrigerants

Objectives
Rank 2L on ISO Standard 817 changed the restriction on refrigerants regarding their flammability and allows for the practical use of low-flammability refrigerants. However, in Japan, only the classifications "non-flammable" and "flammable" are recognized in the High Pressure Gas Safety Act and the Ordinance on the Security of Safety at Refrigeration. With the objective of gathering essential data for the risk assessment of mildly flammable refrigerants, safety studies are being conducted by the nationalproject. Since 2011, these researches have been sponsored by the project "Development on Highly Efficient and Non-Freon Air Conditioning Systems" of the New Energy and Industrial Technology Development Organization (NEDO).

Members and observers
Members:

- The University of Tokyo
- Kyusyu University
- The Tokyo University of Science at Suwa
- The National Institute of Advanced Industrial Science and Technology
- The Japan Refrigerating and Air Conditioning Industry Association
- The Japan Automobile Manufacturers Association
- The Japan Society of Refrigerating and Air Conditioning Engineers

Observers:

- Ministry of Economy, Trade and Industry
- The New Energy and Industrial Technology Development Organization (NEDO)
- High Pressure Gas Safety Institute of Japan
- Kansai Electric Power Co., Inc.

Progress report 2014
Progress report 2014 has been released in June 2015.

- Abstranct in Japanese (899kB)
- Progress report 2014 in Japanese (12,740kB)
- Abstranct in English (1166kB)
- Progress report 2014 in English (12,454kB)

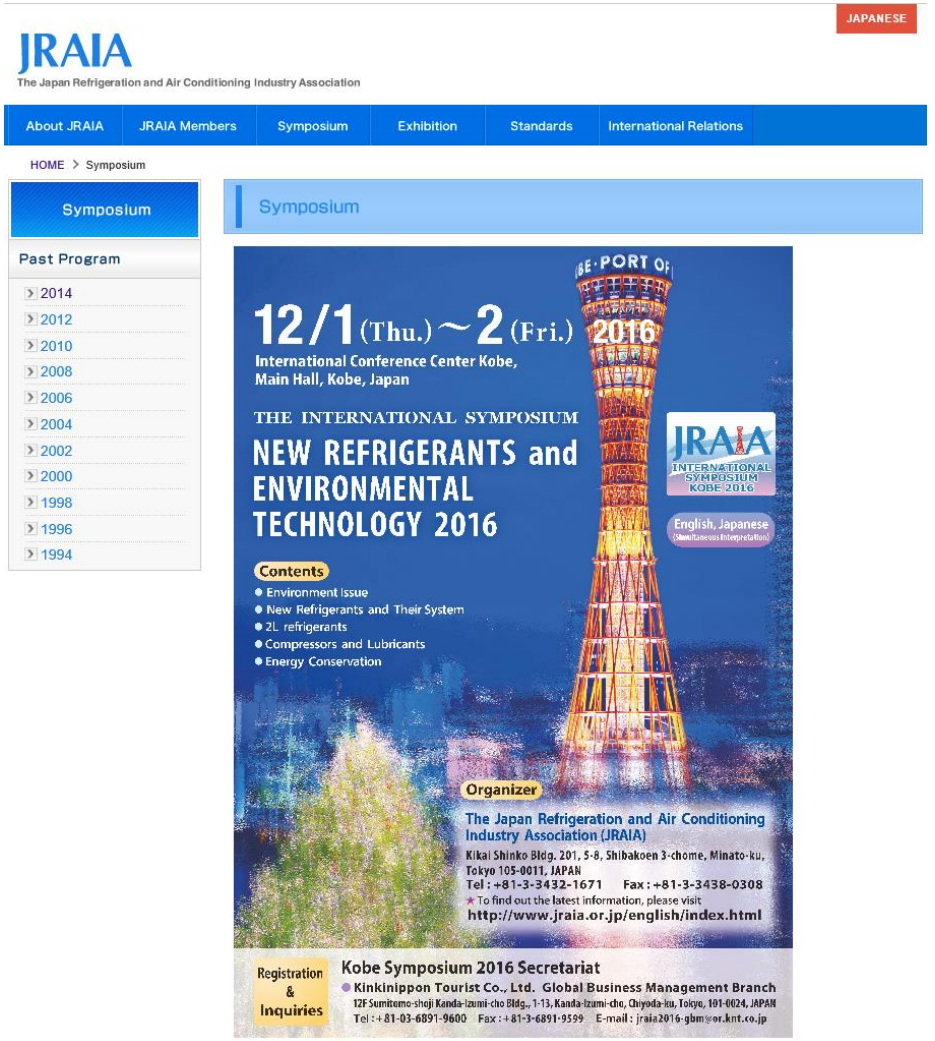
ICR2015 Workshop: Risk Assessment of Mildly Flammable Refrigerants was held on August 20, 2015
Program

1. Opening Remarks, Munehiko TSUCHIYA
2. Overview of NEDO-Project -Technology Development of High-efficiency Non-fluorinated Air-conditioning Systems-, Mika SUZAWA
3. Research Project on Risk Assessment of Mildly Flammable Refrigerants, Eiji HIHARA
4. Fundamental and Practical Flammability Properties of 2L Refrigerants, Kenji TAKIZAWA
5. Hazard assessment of the combustion of mildly flammable refrigerants, Tei SABURI
6. Experimental Evaluation of Physical Hazard of A2L Refrigerant Assuming Actual Handling Situations, Tomohiko IMAMURA
7. Diesel Combustion of Oil and Refrigerant Mixture during Pump Down of Air Conditioners, Chaobin DANG
8. Basic Procedure of the Risk Assessment in JRAIA, Satoru FUJIMOTO
9. Overview of the Risk Assessment for Residential Air-Conditioners, Kenji TAKAICHI
10. Overview of the Risk Assessment for VRF System, Ryuzaburo YAJIMA
11. Overview of the Risk Assessment for Chiller, Kenji UEDA
12. Overview of AHRI Risk Assessment Studies for A2L Refrigerants, Xudong WANG
13. Research on Flammability of the lower GWP refrigerants, Zhao YANG

Copyright and disclaimer
Copyright ©2014 by the authors and JSRAE. This report or any portion thereof may not be reproduced or used in any manner whatsoever without the express written permission of JSRAE except for the use of brief quotations in a book review. Although the authors and JSRAE have made every effort to ensure that the information in this report was correct at press time, the authors and JSRAE do not assume and hereby disclaim any liability to any party for any loss, damage, or disruption caused by errors or omissions, whether such errors or omissions result from negligence, accident, or any other cause.

Contact
Please contact us about any concerns excluding detailed contents of the progress report.
Chairperson: Eiji Hihara, Professor of the University of Tokyo
hihara@k.u-tokyo.ac.jp

http://www.jraia.or.jp/english/symposium/index.html



JRAIA
The Japan Refrigeration and Air Conditioning Industry Association

JAPANESE

About JRAIA | JRAIA Members | Symposium | Exhibition | Standards | International Relations

HOME > Symposium

Symposium
Past Program
2014
2012
2010
2008
2006
2004
2002
2000
1998
1996
1994

Symposium

12/1 (Thu.) ~ 2 (Fri.) 2016
International Conference Center Kobe,
Main Hall, Kobe, Japan

THE INTERNATIONAL SYMPOSIUM
NEW REFRIGERANTS and ENVIRONMENTAL TECHNOLOGY 2016

JRAIA INTERNATIONAL SYMPOSIUM KOBE 2016

English, Japanese (Simultaneous Interpretation)

Contents
- Environment Issue
- New Refrigerants and Their System
- 2L refrigerants
- Compressors and Lubricants
- Energy Conservation

Organizer
The Japan Refrigeration and Air Conditioning Industry Association (JRAIA)
Kikai Shinko Bldg. 2Fl, 5-8, Shibakoen 3-chome, Minato-ku, Tokyo 105-0011, JAPAN
Tel : +81-3-3432-1671 Fax : +81-3-3438-0308
★To find out the latest information, please visit
http://www.jraia.or.jp/english/index.html

Registration & Inquiries
Kobe Symposium 2016 Secretariat
Kinkinippon Tourist Co., Ltd. Global Business Management Branch
12F Sumitomo-shoji Kanda-Izumi-cho Bldg., 1-13, Kanda-Izumi-cho, Chiyoda-ku, Tokyo, 101-0024, JAPAN
Tel : +81-03-6891-9600 Fax : +81-3-6891-9599 E-mail : jraia2016-gbm@or.knt.co.jp