Transition of refrigerants for air-conditioners in high ambient temperature region

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Who is JRAIA?

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The Japan Refrigeration and Air Conditioning Industry Association

<The Japan Refrigeration and Air conditioning Industry Association>

- Established in 1949.
- 159 member companies (as of 1st of Oct. 2015) including the associate members.
- The business fields of the member companies:
  -Air conditioning (domestic, commercial, automotive)
  -Refrigeration (commercial, Industrial)
  -Ventilation
  -Chiller
  -Heat pump system(HP water heaters)
  -Refrigerants
  -Parts

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1. Key Factors for alternative refrigerants

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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

2. Simulation results of alternative refrigerants

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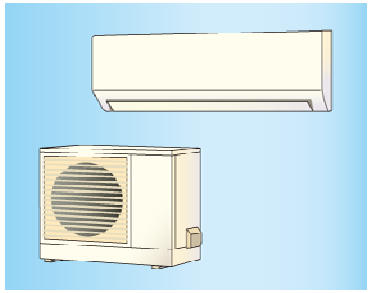
Refrigerants:

	R410A	R32	R447A	R22	R290
Flammability	A1	A2L	A2L	A1	A3
GWP	2088	675	583	1810	3



Base AC model:

Single Split AC with R410A currently on sales in Middle East

・capacity: **7.0kW** ・capillary ・constant speed compressor

Conditions:

・Specification, e.g. refrigerant amount, compressor rotating speed, expansion device (capillary/expansion valve) was determined to perform **7kW at AHRI-A** condition with each refrigerant.

・Evaluation was carried out with the determined specification at each temperature.

・Superheat at evaporator outlet = 0 degK, discharge temperature < 115℃

	Outdoor	Indoor	
	DB（℃）	DB（℃）	WB（℃）
AHRI-A	35.0	26.7	19.4
T3	46.0	29.0	19.0
AT＝52℃	52.0	29.0	19.0
AT＝55℃	55.0	29.0	19.0

2. Simulation results of alternative refrigerants

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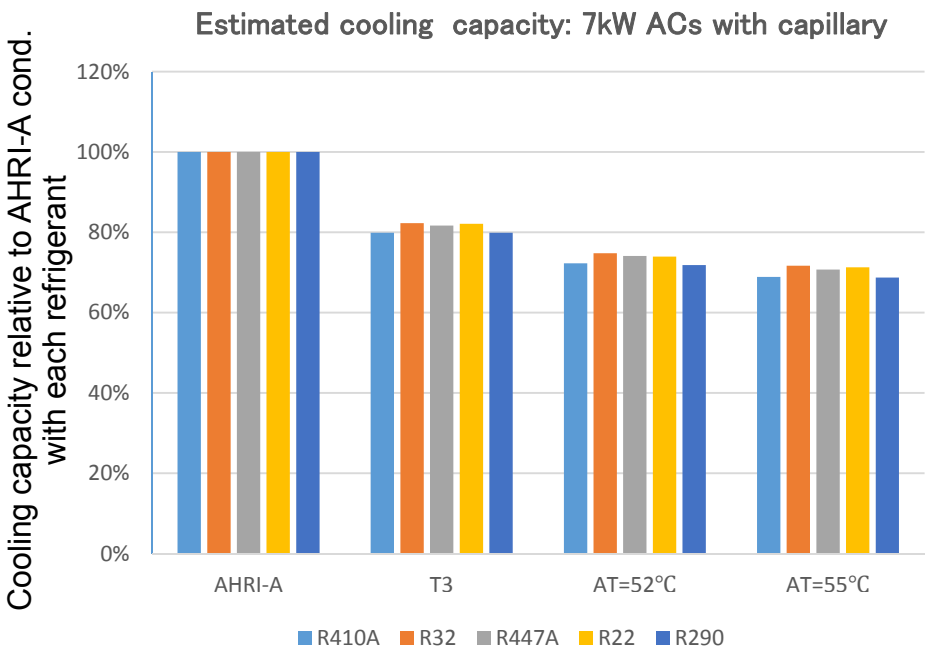
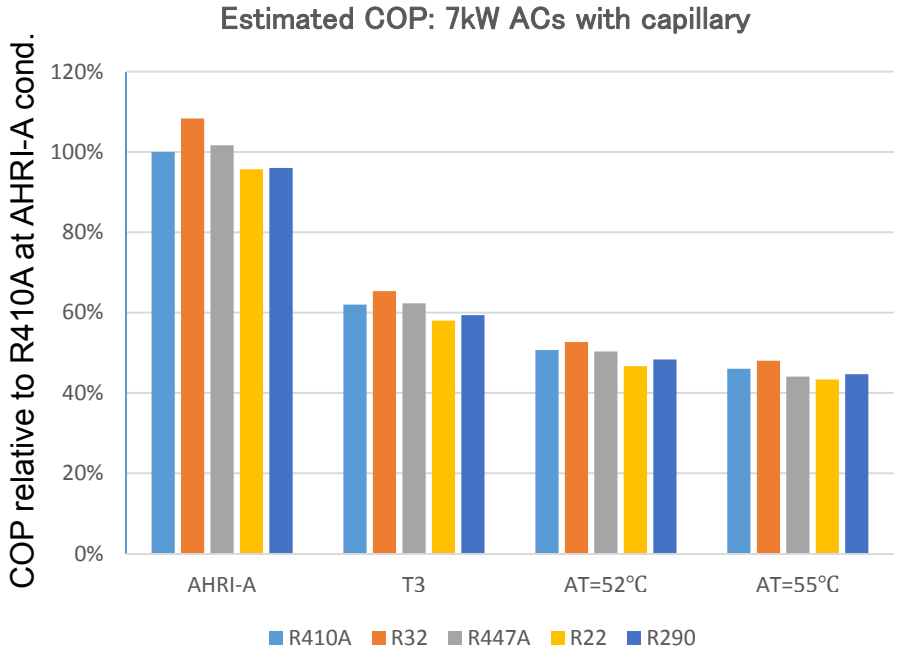
1）Cooling capacity and COP vs ambient temperature

・**Cooling capacities** with all refrigerants in this study **decrease** similarly **at high ambient temperature** conditions.

・**COPs** with all refrigerant in this study also **decrease** similarly **at high ambient temperature** conditions.（COPs relative to R410A at AHRI-A condition for each refrigerant are shown for the comparison.）





2. Simulation results of alternative refrigerants

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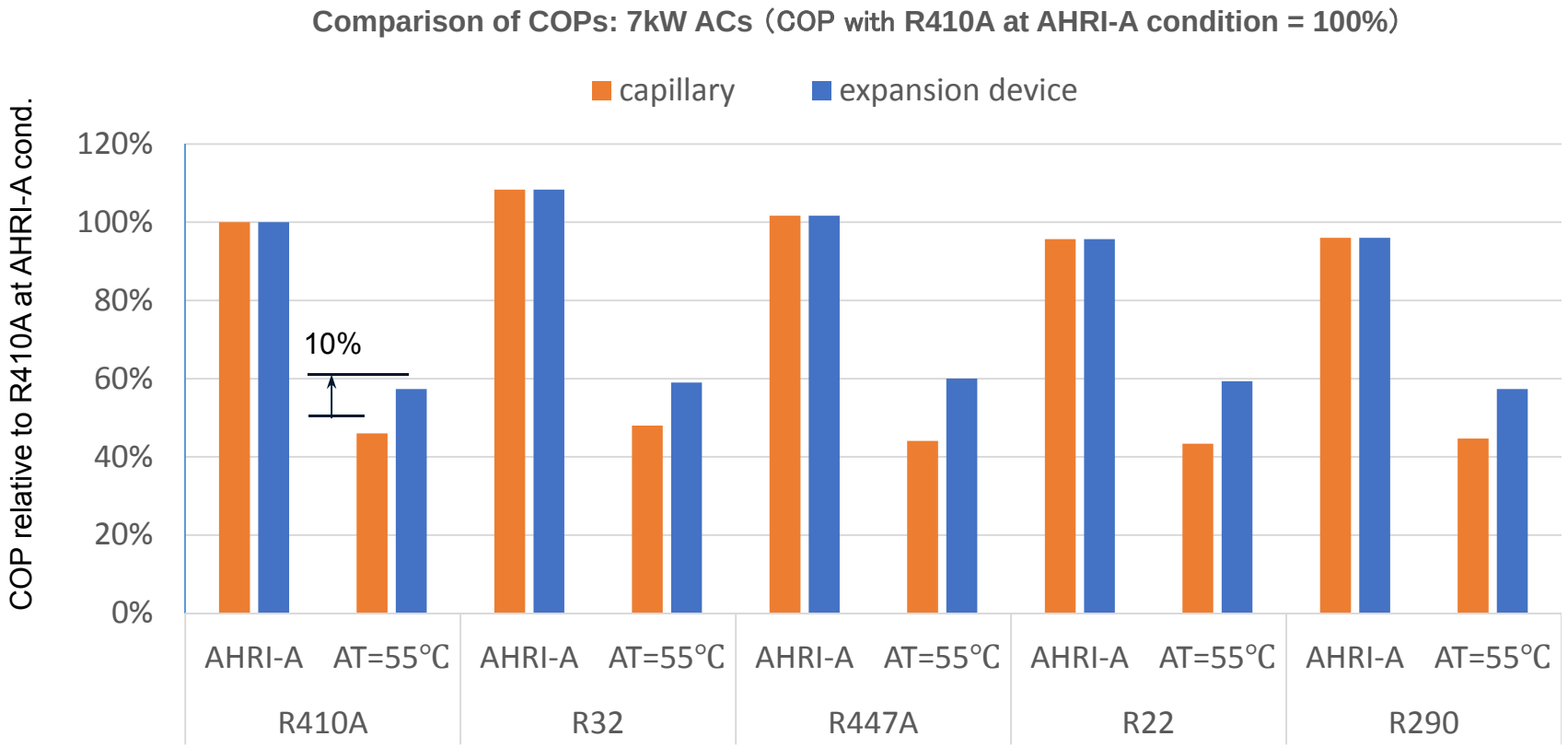
2）Improvement of COP with **optimized expansion device**

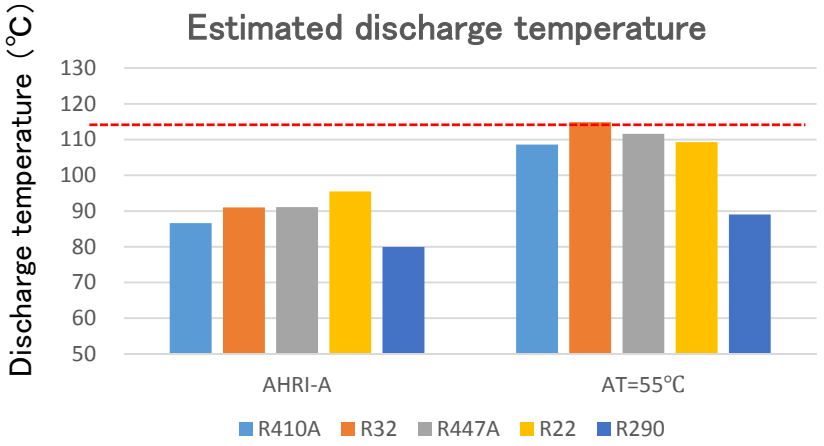
・By optimizing expansion device at each temperature condition of each refrigerant, **COP can be improved approximately by 10%**. Optimization of expansion device is one of effective technical solutions for energy saving to protect global environment.



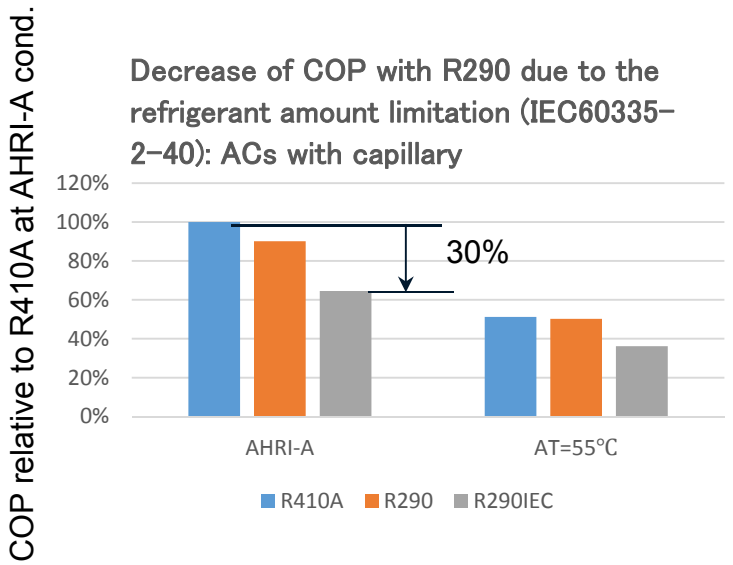
2. Simulation results of alternative refrigerants

3) Technical points to be considered

① Higher discharge temperature (Td) at high ambient temperature.



② Lower COP due to the refrigerant amount limitation related to safety
Under the limitation according to IEC60335-2-40,
the **COP with R290 is lower than that with 410A by 30%.**



3. Risk Assessment for lower flammability refrigerants

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Activities in Japan: Residential single split ACs case(example)

Safety criteria: **(Use) Ignition probability ≒ 10^{-10}** --- equivalent to the a lethal damage probability
: once a century for a hundred million (10^8) market stock
(Others) Ignition probability ≒ 10^{-9}

Life cycle of products	Ignition probability A2L (ex.R32)
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 whole of life cycle** was conducted.
- Residential split ACs were placed on the market after confirming the acceptable risk level.
- 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.

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

3. Risk Assessment for lower flammability refrigerants

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Risk assessments has been carried out in Japan for lower flammability refrigerants (A2L). Studies are ongoing for various types of products.

→ **<u>Legislation and/or harmonization of safety regulation for these products should follow</u>.**

		Risk Assessment (A2L)	Current situation
Split	Residential	Completed in 2013	The shipment of high walls with R32 has reached approx. 100% in 2015.
	Commercial (smaller products)	Completed in 2015	Started to place on market.
VRF, Chiller, GHP		Completed in 2015	Safety guideline under discussion
Refrigeration		Ongoing (-2016)	RA Ongoing

4. Conclusions

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1) Refrigerant should be selected appropriately by considering comprehensive point of views:
Safety, **Environment Performance**,
Energy efficiency and **Economic feasibility**.
2) The candidates of the alternative refrigerant are lower flammability(A2L), flammable (A2) or higher flammability (A3). Therefore, **Risk assessment should be conducted** and legislation is needed depending on the risk level.
3) The **alternative refrigerants** in this study **perform as well as R410A under high ambient temperature** conditions.
4) By optimizing expansion device at each temperature condition of each refrigerant, COP can be improved. Optimization of expansion device is one of effective technical solutions for energy saving to protect global environment.
5) **Harmonization with the safety law** should be needed.

Thank you for your kind attention.

[IEC60335-2-40, GG2]

Maximum charge [kg]

$$m_{max} = 2{,}5 \times (LFL)^{(5/4)} \times h_0 \times (A)^{1/2}$$

LFL: lower flammability limit [kg/m3]

h0: height of unit [m]

A: floor are [m2]

2. Simulation results of alternative refrigerants

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Comparison between the results in this study and that in IEP(HATP) project

- Similar results were obtained in both studies.