ET Summit 2019

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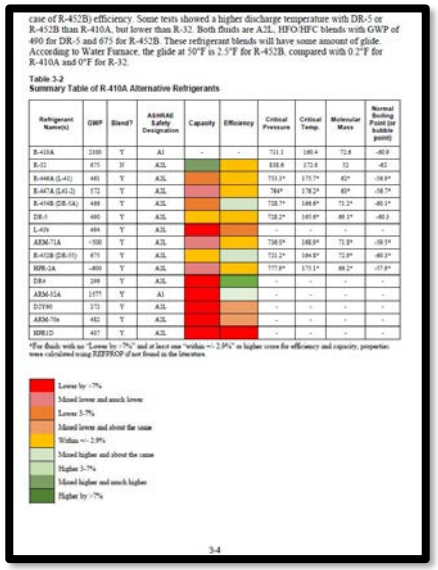
Refrigeration and Refrigerants

Examples of EPRI Projects

Ammi Amarnath
Sr. Technical Executive
Electric Power Research Institute

Overview: Refrigeration & Refrigerants

- Many HVAC&R categories face pressing changes
  - U.S. EPA, California ARB
  - Some applications have major changes happening very soon
- Near term alternatives?
  - Retrofits, “drop-ins”, and near-term new equipment
  - Nearly all new alternatives require some compromise
    - Efficiency, capacity, safety
- EPRI Work:
  - Summary of extensive third party tests
    - Key information to understand requirements, safety etc
  - Completed and ongoing field work
    - Project using low-charge ammonia/CO_2 at Imuraya (SCE)
    - Project using ultra low-charge ammonia at Takara (CEC EPIC)
    - Project on heat pumps at residential sites in California (CEC EPIC)



case of R-452B) efficiency. Some tests showed a higher discharge temperature with DR-5 or R-452B than R-410A, but lower than R-32. Both fluids are A2L. HFO/HFC blends with GWP of 490 for DR-5 and 675 for R-452B. These refrigerant blends will have some amount of glide. According to Water Furnace, the glide at 50°F is 2.5°F for R-452B, compared with 0.2°F for R-410A and 0°F for R-32.

Table 3-2
Summary Table of R-410A Alternative Refrigerants

Refrigerant Name(s)	GWP	Blend?	ASHRAE Safety Designation	Capacity	Efficiency	Critical Pressure	Critical Temp.	Molecular Mass	Normal Boiling Point (or bubble point)
R-410A	2100	Y	A1	-	-	711.1	160.4	72.6	-60.6
R-32	675	N	A2L			838.6	172.6	52	-62
R-444A (L-41)	140	Y	A2L			733.3*	173.7*	82*	-54.9*
R-447A (L41-2)	572	Y	A2L			764*	170.2*	85*	-58.7*
R-454B (DR-5A)	466	Y	A2L			728.7*	166.6*	73.2*	-60.1*
DR-5	490	Y	A2L			728.2*	165.9*	69.1*	-60.3
L-41b	494	Y	A2L			-	-	-	-
ARM-71A	<500	Y	A2L			736.0*	168.9*	71.8*	-58.3*
R-452B (DR-55)	675	Y	A2L			721.2*	164.8*	72.8*	-60.3*
HPR-2A	~600	Y	A2L			777.8*	173.1*	66.2*	-57.9*
DR4	299	Y	A2L			-	-	-	-
ARM-35A	1477	Y	A1			-	-	-	-
D2Y60	172	Y	A2L			-	-	-	-
ARM-70a	482	Y	A2L			-	-	-	-
HBR1D	467	Y	A2L			-	-	-	-

*For fluids with no "Lower by >7%" and at least one "within +/- 2.9%" or higher score for efficiency and capacity, properties were calculated using REFPROP if not found in the literature.

Lower by >7%
Mixed lower and much lower
Lower 3-7%
Mixed lower and about the same
Within +/- 2.9%
Mixed higher and about the same
Higher 3-7%
Mixed higher and much higher
Higher by >7%

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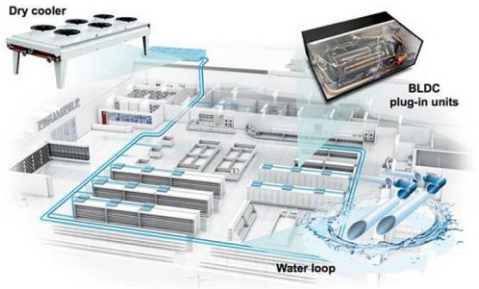
Refrigerant Multi-funder Supplemental Project

Alternative Refrigerants for Enhancing Customer Value (Refrigerant Collaborative)

- Multi-Funder Collaborative
  - *Funders – SCE, BPA, SDG&E, and Southern Co.*
- How will refrigerant changes impact the industry?
  - *Summarize the changes, the options, and the impacts/opportunities*
- For tech(s) of interest:
  - *In-depth review and laboratory/field evaluation*
- Low-Charge Ammonia Refrigeration
  - *Opportunities for refrigerated warehouse*
  - *Also industrial applications*



Low Charge Ammonia/CO_2 Refrigeration Project at Imuraya

- **Project Partners**

EPRI ELECTRIC POWER RESEARCH INSTITUTE

imuraya

SOUTHERN CALIFORNIA EDISON

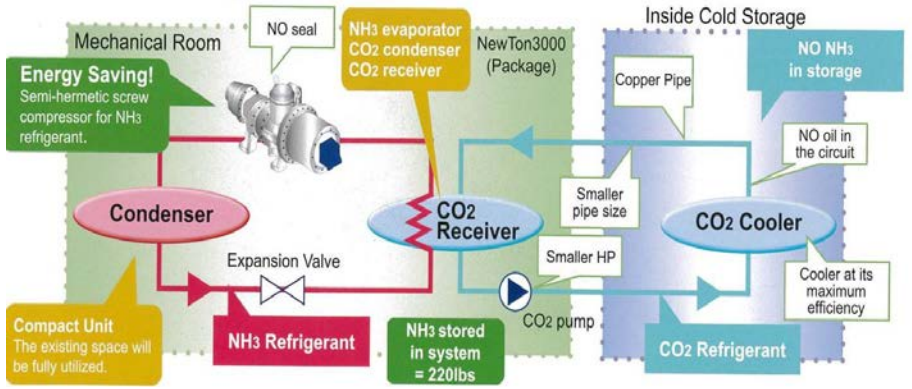
MAYEKAWA MYCOM

Source: Imuraya

Low Charge Ammonia/CO_2 Replacing R507A Refrigerant

- 2,100 square foot freezer at -20^{0}F
- NewTon 3000 from Mayekawa
  - Low charge ammonia primary, CO_2 secondary
  - 2 stage compact screw compressor
  - VFD speed control
  - Double economizer
- First U.S. installation
- 30% premium in first cost
- Installation similar to standard
- Total energy savings = ~30%

Source: ASHRAE Journal Article February 2017



Source: Mayekawa

CEC EPIC Project: Ultra-Low Charge Ammonia Refrigeration System

Big Picture

- Advancing new ultra-low charge ammonia chiller in industrial sector
- Highly efficient, zero GHG, air source (water savings)
- Applications in food processing, walk-in coolers, supermarkets etc.

Primary Objective

- Pilot an advanced natural refrigerant based process cooling system

Potential Benefits

- Annual energy savings of 4,703 GWh
- Annual water savings of 8,467 million gallons of water

Partners

- CEC, EPRI, Mayekawa, EdF Innovation Labs, Takara

CALIFORNIA ENERGY COMMISSION

CEC Award #: EPC-16-048

CEC EPC-16-048: Project Partners

- Funder:

CALIFORNIA ENERGY COMMISSION

- Prime:

EPRI ELECTRIC POWER RESEARCH INSTITUTE

- Technology Provider & Subcontractor:

MAYEKAWA MYCOM

eDF

- Cost share/ co-funding:

EPRI ELECTRIC POWER RESEARCH INSTITUTE

TaKaRa TAKARA SAKE USA INC.

- Demonstration Site:

TaKaRa TAKARA SAKE USA INC.

- Support and Tech Transfer

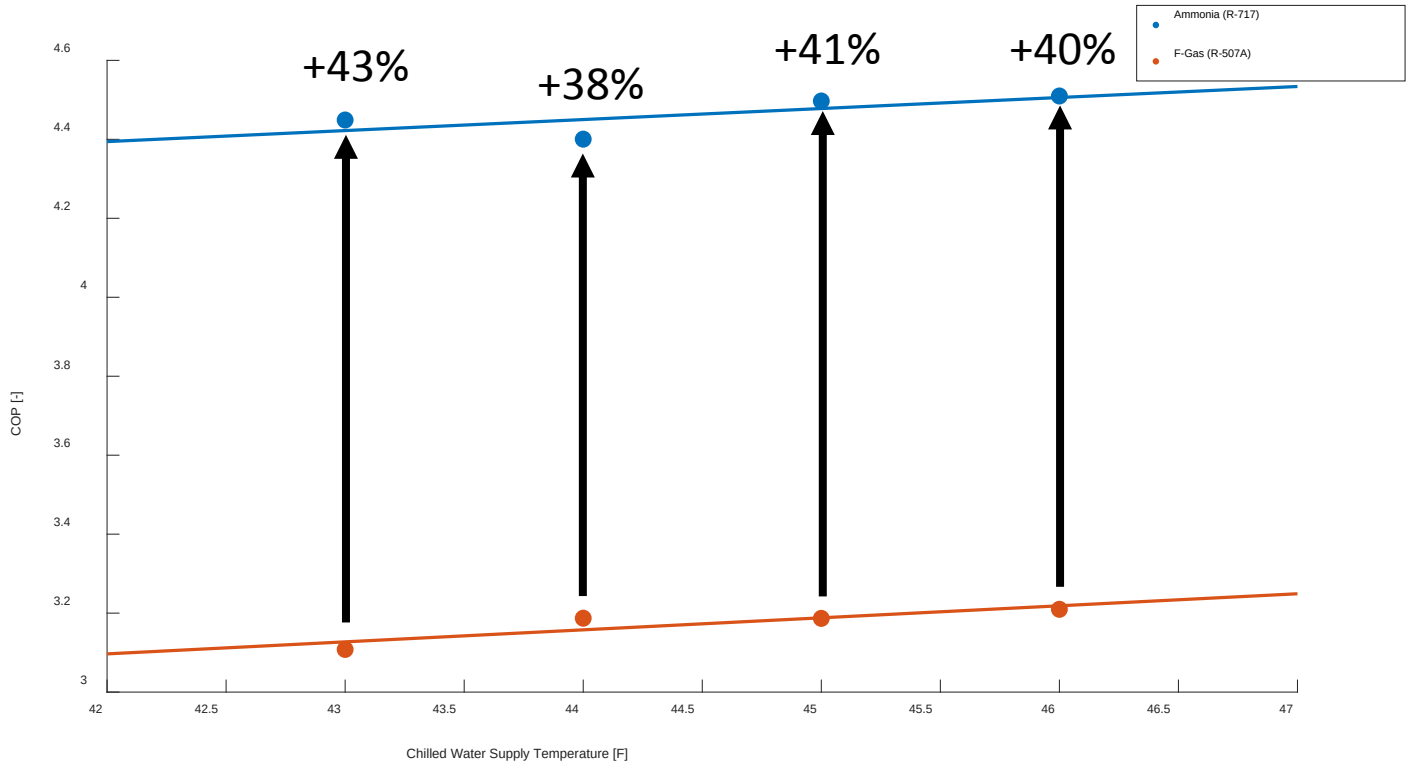
SOUTHERN CALIFORNIA EDISON

Chiller Performance (70-80% capacity) with Chilled Water Supply Temperature

COP	R-507A	R-717
43°F	3.11	4.45
44°F	3.19	4.40
45°F	3.19	4.50
46°F	3.21	4.51

Filters:

- Ambient Dry Bulb 65-70 °F
- Chiller Capacity 70-80%
- Compressor power 5+ kW



Note: This is work in progress; final results may vary

Ammonia chiller show ~40% efficiency improvement.

The R-507A chiller's COP averaged 3.17. The R-717 chiller's COP averaged 4.46.

Some Thoughts

- Low GWP refrigerant technology is here today
- Higher efficiency observed while using certain refrigerants
- Low charge ammonia and CO_2 refrigerants have good opportunity
- Higher first costs, but savings through the life of the project

Thank you!

Ammi Amarnath

Sr. Technical Executive

EPRI

aamarnath@epri.com

www.epri.com