CO2-AMMONIA-R404A SYSTEM FOR FREEZING

PRESENTED BY : HIROYUKI EGASHIRA
MAYEKAWA MFG.CO., LTD. TOKYO, JAPAN

1

About Speaker

Mr. Hiroyuki Egashira
A Founder Committee member of Association of Ammonia Refrigeration
A former MD of Mayekawa India Pvt. Ltd.
Worked in India from 2006 to 2016.
Retired from Mayekawa Mfg. Co., Ltd. on March., 2020.
Currently, working as a Senior Advisor, South Asia Region Operation and Business Development for Mayekawa Mfg. Co., Ltd.
Mobile: +81-8010085252
E-mail: hiroyuki-egashira@Mayekawa.co.jp

2

Contents

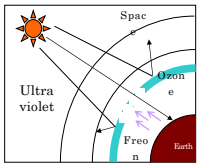
3

Back Ground

Ozone Depletion

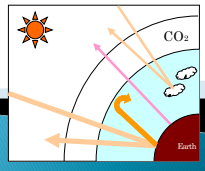
The ozone layer is damaged by HCFC, CFC refrigerants. This increases amount of ultra violet rays that reach to the earth's surface. It harms all live creatures on the earth (i.e., skin cancer, weaken immunization, decrease in crops).

It is our responsibility to stop using any Ozone Depletion Refrigerant such as HCFC and CFC.



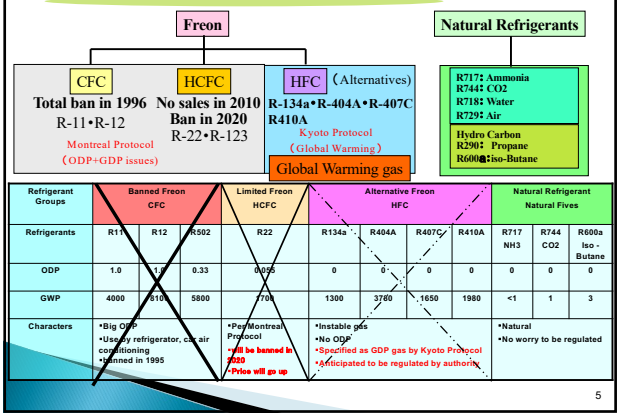
Global Warming

By burning fossil fuels such as petroleum, coal, and cutting trees, The oxidized waste such as CO_2, SO_x, NO_x, increases in earth atmosphere. This causes global warming and acid rain. This is also caused by HCFC and CFC refrigerants.
It is predicted that about a 5 F raise in global temperature will occur by year 2000. This will raise the sea level by 2.1 ft.
We must reduce amount of waste of oxidized gas, reduce usage of electric power which was created by fossil fuel.



4

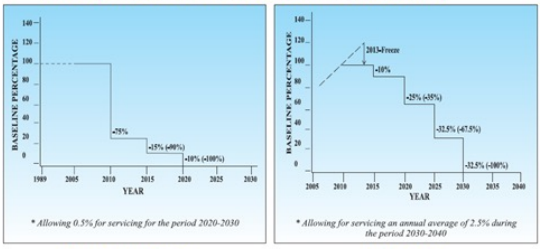
Future of refrigerants has changed



5

- Current legislation scenario Global level (Montreal Protocol)

HCFC phase-out schedule for parties (revised MP)

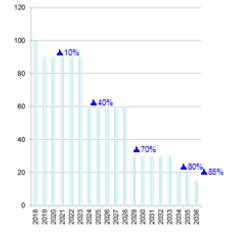


Non-Article 5 Parties | Article 5 Parties

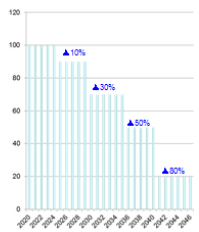
6

- Current legislation scenario Global level (Montreal Protocol)

HFC phase-out schedule for parties (MP Kigali Amendment)



Developed Countries



Developing Countries

6

7

Phase out plan of HFC in India

As per the Kigali Amendment, India will complete its phase down of production and consumption of HFCs for controlled uses in four steps from 2032 onwards with cumulative reduction of

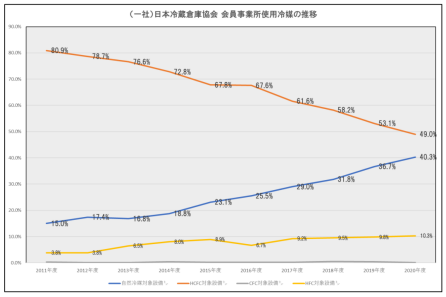
10% in 2032
20% in 2037
30% in 2042
85% in 2047

8

8

Status in Japan

ATMO Summit



27/06/2022 - TOKYO
28/06/2022 - ONLINE

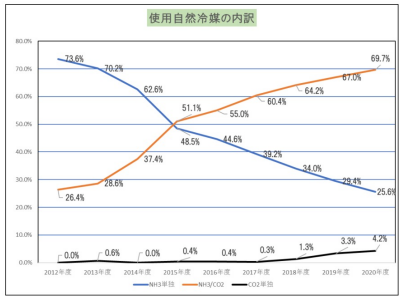
#GoNatRefs

2nd Feb 23 AAR ARCON 2023 Chennai 9

9

Status in Japan

ATMO Summit



27/06/2022 - TOKYO
28/06/2022 - ONLINE

#GoNatRefs

2nd Feb 23 AAR ARCON 2023 Chennai 10

10

5 systems

- 1. R404A
- 2. AMMONIA
- 3. AMMONIA-CO2 CASCADE
- 4. AMMONIA-CO2 BRINE
- 5. CO2 TRANSCRITICAL

2nd Feb 23 AAR ARCON 2023 Chennai 11

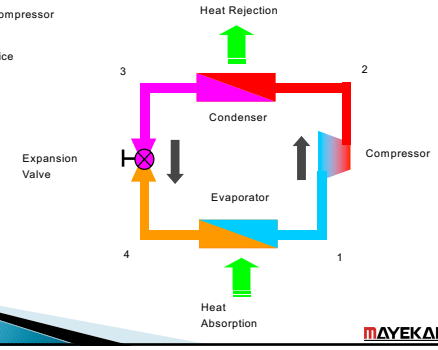
11

R404A SYSTEM

1. DIRECT EXPANSION SYSTEM

consist of the following:

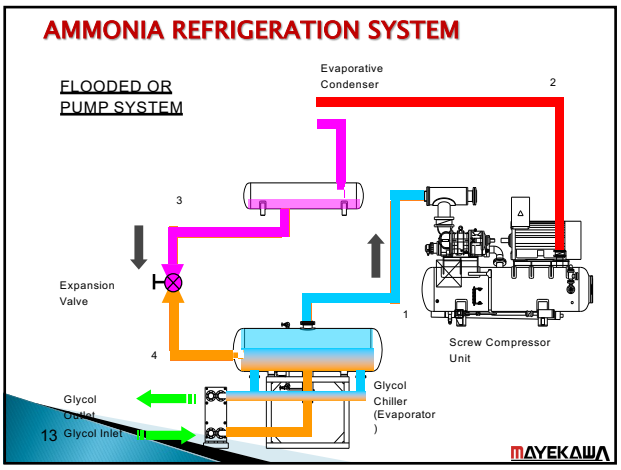
- Single Stage Compressor
- Condenser
- Expansion Device
- Evaporator



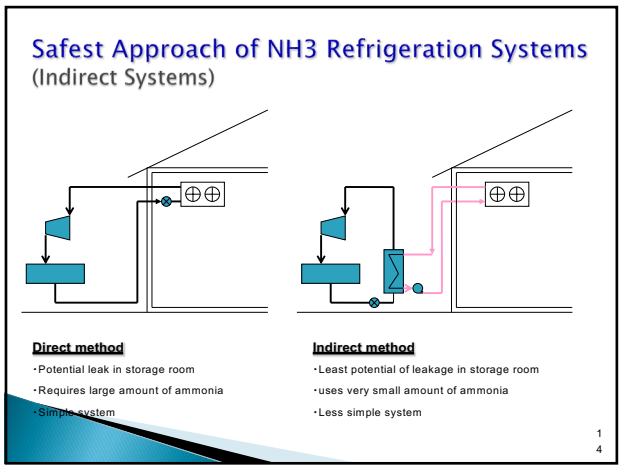
12

MAYEKAWA

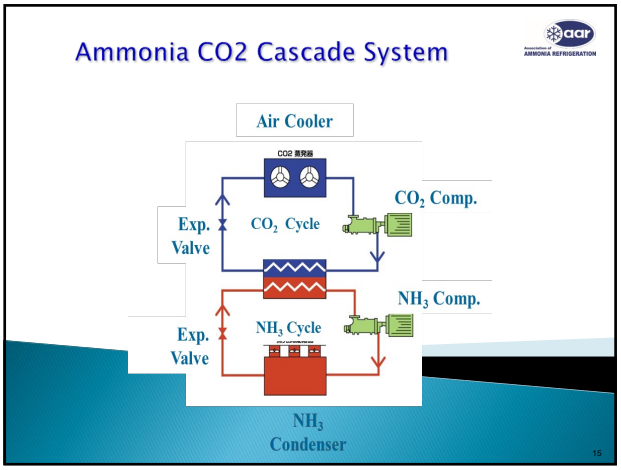
12



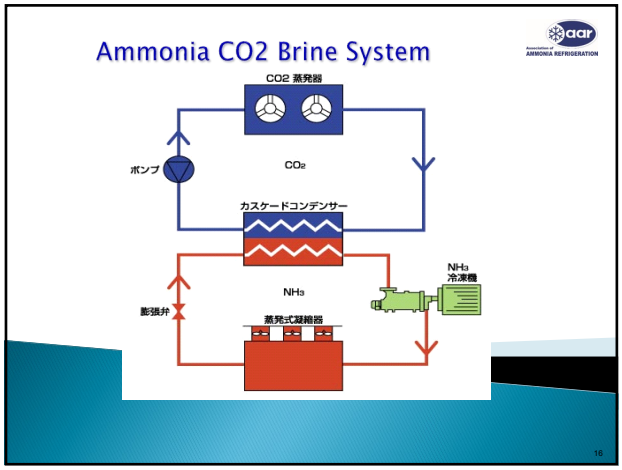
13



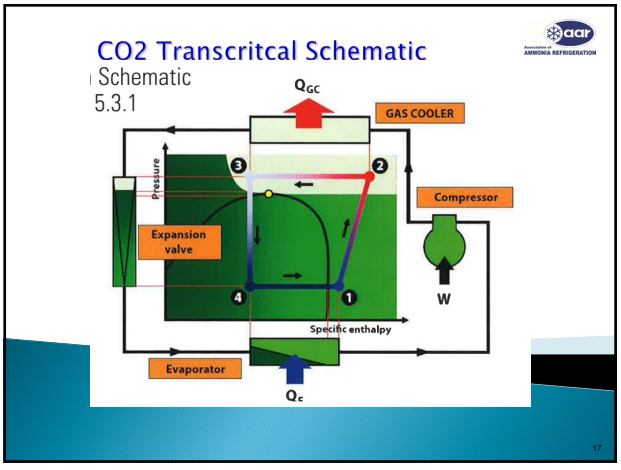
14



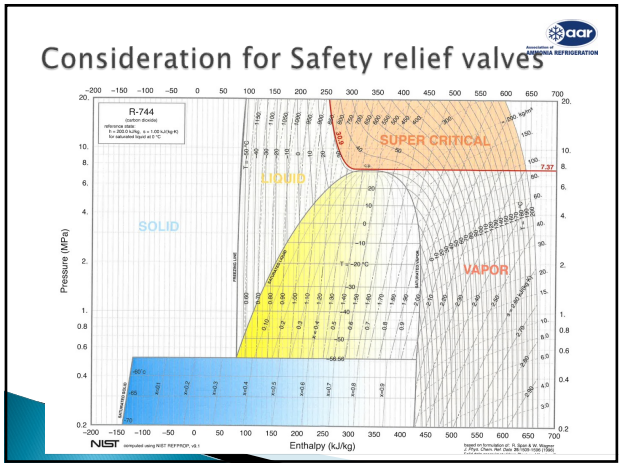
15



16



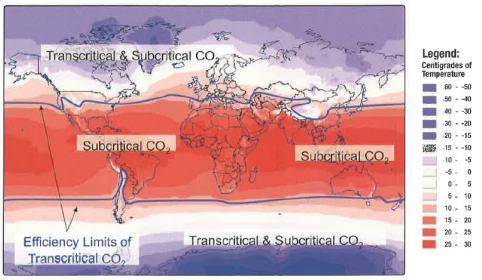
17



18

Why CO2 transcortical is not relevant in India

Fig. 1.2 Potential Global Distribution: CO_2-System Alternatives:



19

Comparison of Capital Cost

Compressor Swept Volume/Suction Pipe Sizes		
For 100TR at -40 deg.C., with intermediate temperature of -5deg.C.		
	Required Swept Volume (m3/hr)	Suction Pipe Dia (mm)
NH3	1,628	250
CO2	206	100
R404A	1,263	250

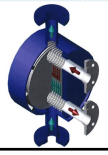
2nd Feb 23 AAR ARCON 2023 Chennai 20

20

Comparison of Capital Cost

	Piping work	Intermediate
NH3	Steel Pipes, argon or arc weld	Flooded type Intercooler
CO2	Stainless steel pipes, cupper pipes	Cascade Condenser
R404A	Cupper pipes	Direct expansion intercooler

	Operating Pressure(MPaA)		
	Condensing(40deg.C)	Condensing(-5deg.C)	Evaporating (-40deg.C)
NH3	1.55		0.072
CO2		3.05	1.00
R404A	1.84		0.136

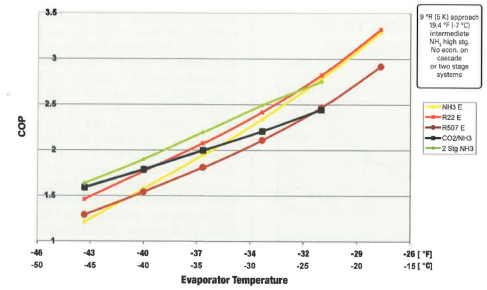


2nd Feb 23 AAR ARCON 2023 Chennai 21

21

Comparison of Operational Cost

Fig. 5.4.1 Energy Comparison: Various Refrigerant Options



2nd Feb 23 AAR ARCON 2023 Chennai 22

22

A CALCULATION FOR AN EXAMPLE IN INDIA

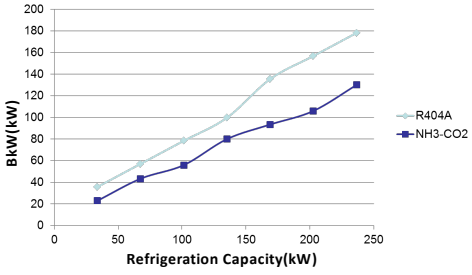
System Outline

Freezer			
Room Temp:	-18 deg.C.		
No. of Room	7 Rooms		
Room Size (m)	L	W	H
	8.5	20.5	12.5
Pallte Per Room	350 pallet		
Estimated Capacity	28.8 kW		
Compressor			
Carlyle 06CC899F200	8 sets (1set stand-by)		
Chilled and Loading Area			
Room Temp:	5 deg.C.		
No. of Room	3 Rooms		
Room Size	L	W	H
	8.5	20.5	12.5
Pallte Per Room	350 pallet		
Compressor			
Carlyle 06EM799601	4 sets (1set stand-by)		

23

Impact of Ammonia CO2 System against Freon System/Estimate

BkW comparison at partial load for same refrigeration load.



NH3-CO2 system against R404A system.

24

MAYEKAWA

24

Impact of Ammonia CO2 System against Freon System/Estimate

%	Existing BkW	BkW	BkW difference	Running hour/month	Saving/month in INR	Saving/Year in INR
100	156.1	110.6	45.4	540	154,588.–	1,855,065.–
80	127.3	88.8	38.5	540	130,951.–	1,571,420.–
60	90.8	68.3	22.4	540	76,287.–	915,449.–

The cold storage of 350 pallets x 7 rooms.
By changing refrigerant from R404A to Ammonia-CO2, the power reduction of approx.30% is achievable.
This can be INR10,00,000 reduction of Power cost in a year.

- **Running hour is based on 18hrs/day operation**
- **Assumed Power cost is Rs.6.3-/kWh.**

25

Summary

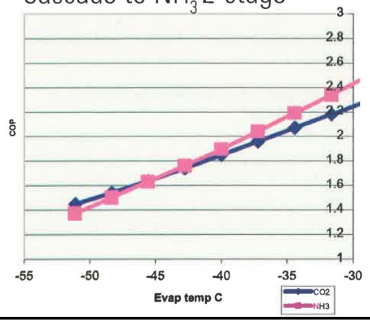
This power savings apply to following 3 systems

- 2. AMMONIA
- 3. AMMONIA–CO2 CASCADE
- 4. AMMONIA–CO2 BRINE

26

Cascade Temp = 20 °F (-6.67 °C) app. temp: 6 °F (3.33 °C)

Energy Comparison: CO_2 /NH_3 Cascade to NH_3 2-stage



27

Summary

Ammonia system is more efficient than Ammonia–CO2 Cascade system at Te above –45deg.C.

Ammonia–CO2 brine system is more efficient than Ammonia–CO2 Cascade system at Te above –40deg.C.

28

Extra Maintenance requirement of Ammonia–CO2 Cascade System

1. **NH3-CO2 Cascade system requires CO2 compressors.**
2. **NH3-CO2 Cascade system requires CO2 compatible compressor oil.**

   POE, PAG-miscible with CO2. Hygroscopic.

   PAO-immiscible with CO2. Not Hygroscopic. Need highly efficient oil separators
3. **NH3-CO2 Cascade system requires oil removal from CO2 circuit. Otherwise, the efficiency will go down.**

29

Human Hazard of Ammonia and CO2

	CO2	NH3
Threshold Limit Value(TLV)	5000ppm(0.5%)	2.5ppm
Short term Exposure Limit '15min)	15000/30000 ppm(1.5/3%)	35ppm
Immediately Dangerous to Life or Health Concentration	40,000ppm(4%)	300ppm

R404A EXPOSURE GUIDE LINE

INGREDIENT NAME	ACGIH TLV	OSHA PEL	OTHER LIMIT
Pentafluoroethane	None	None	*1000 ppm TWA (Shr)
1,1,1-Trifluoroethane	None	None	*1000 ppm TWA (Shr)
1,1,1,2-Tetrafluoroethane	None	None	*1000 ppm TWA (Shr)

* = Workplace Environmental Exposure Level (AIHA)

OTHER EXPOSURE LIMITS FOR POTENTIAL DECOMPOSITION PRODUCTS:
Hydrogen Fluoride: ACGIH TLV: 2 ppm ceiling, 0.5 ppm TLV-TWA

30

Consideration for CO2 leakage

CO2 is heavier than air.
In case of large leakage in the cold storages and poorly ventilated machine rooms, it will stay at the floor.

The concentration of CO2 can be high at the less amount of leakage at the floor level.
Gas detectors are must for CO2 system.

31

Consideration for CO2 leakage

Risk of human death due to CO2 are:
Asphyxiation: At 10% concentration, loss of consciousness ensues in few minutes.
Clogging of the vent line with CO2 solid, which burst out.

32

Internal leakage of CO2 to Ammonia

CO2 and NH3 will form Ammonium Carbanate.
This is a hard solid white crystal that will clog strainer, relive valve port and other small passages.

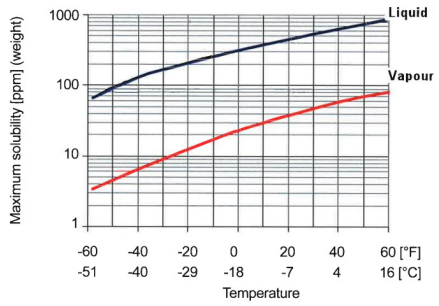
33

Water management in the CO2 system

Water solubility in CO2 is much lower than Ammonia. Once the water level exceeds the solubility level of the temperature, H2O molecules precipitate out of the solution into droplets.
This forms ice and carbonic acid, which, when mixed with water, become corrosive

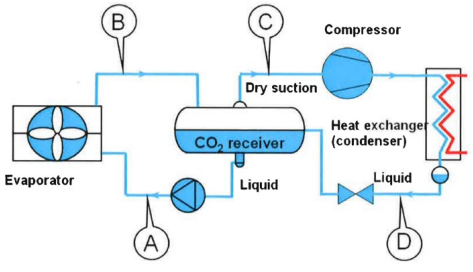
34

Fig. 6.5.1 Water Solubility in CO_2



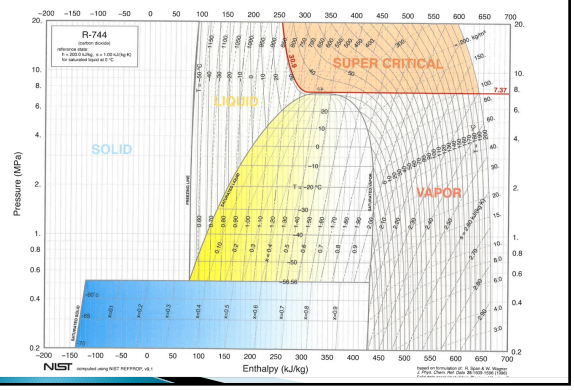
35

Fig. 6.5.2 Water Distribution in CO_2 Pump Circulating Systems



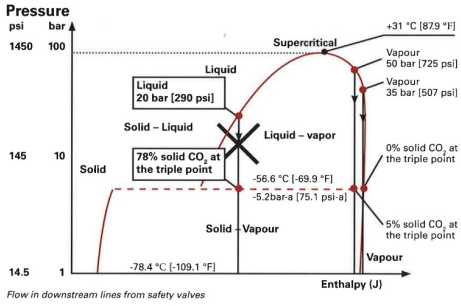
36

Consideration for Safety relief valves



37

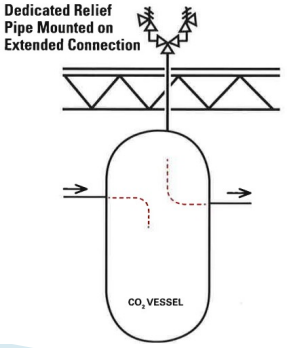
Fig. 6.6.1 Safety Valves in CO_2 Systems



Flow in downstream lines from safety valves

38

Fig. 6.6.2 Roof Penetrations



39

धन्यवाद

நன்றி

हीरोयुकी एगासीरा
ஹிரோயுக்கி ஏகஷிரா
HIROYUKI EGASHIRA
Mobile: +81-8010085252
E-mail: hiroyuki-egashira@Mayekawa.co.jp

40