



42. MEĐUNARODNI KONGRES O GREJANJU, HLAĐENJU I KLIMATIZACIJI
42nd INTERNATIONAL CONGRESS ON HEATING, REFRIGERATING AND AIR - CONDITIONING
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MAYEKAWA

MAYEKAWA Europe nv/sa

Presented by Jan Boone, MAYEKAWA

LINE-UP NATURAL 5

"Natural Five" Refrigerants and Product Solutions

| Refrigerant (Natural Five) | NH ₃ R-717 | CO ₂ R-744 | HC Hydrocarbon | H ₂ O R-718 | Air R-728 |
|----------------------------|--|---|---|---|--|
| 90°C | | Utility hot water | | | |
| 60°C | Utility hot water | | Utility hot water | Heat recovery | |
| 10°C | Chilled water Ice making | Chilled water Ice making | Heating HVAC | Chiller | |
| -15°C | Cold storage, Freezer, Fish boat | | | | |
| -25°C | Specific Refrigeration needs | | | | |
| -40°C | Freezer, Freeze-dry, Super Low temp storage | | | | |
| -50°C | | | Cryogenics | | Cryogenics |
| -60°C | | | | | |
| -100°C | | | | | |
| Notes | <ul style="list-style-type: none"> •Conventional system | <ul style="list-style-type: none"> •Eco-Cute | <ul style="list-style-type: none"> •Nat'l Proj. •Butane + Propane | <ul style="list-style-type: none"> •Nat'l Proj. •Adsorption •Heat recovery | <ul style="list-style-type: none"> •Nat'l Proj. •Air-cycle |

Air Cycle Refrigeration Packaged Unit

2003 Developed at [Technical Strategy for Rationalization of Energy Consumption Project]
~2005 NEDO



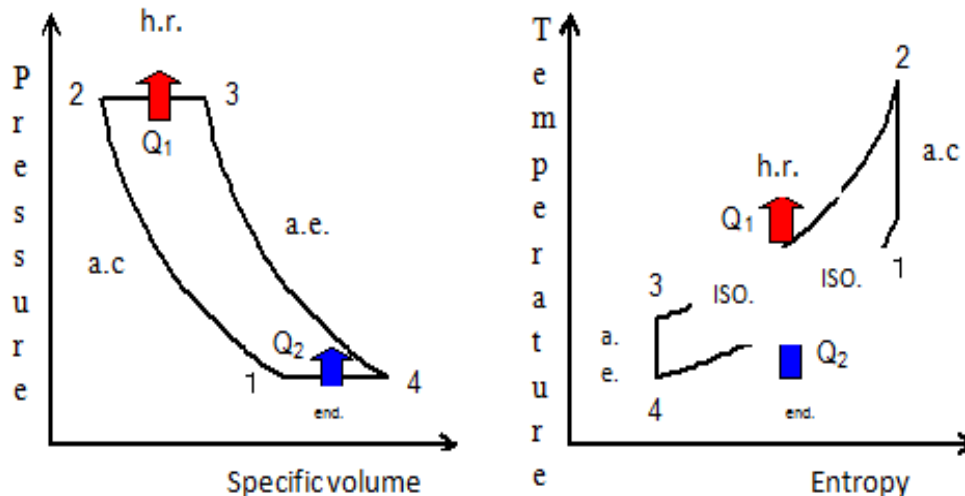
**ULTIMATE NATURAL REFRIGERANT
'AIR'
FOR ULTRA LOW TEMPERATURE
REFRIGERATION**

Mayekawa Mfg.Co,Ltd
A.Machida

PRINCIPLES OF AIR REFRIGERATION SYSTEMS

AIR = most natural refrigerant
 ODP, GWP, TOXICITY, FLAMMABILITY = 0
 Air cycle = transcritical as $T_{critical} (-140.7^{\circ} C)$,
 uses only gas without phase transition.
 Principle : cooling down of compressed air
 before expanding resulting in
 low temperatures in range of -50 to $-100^{\circ} C$.

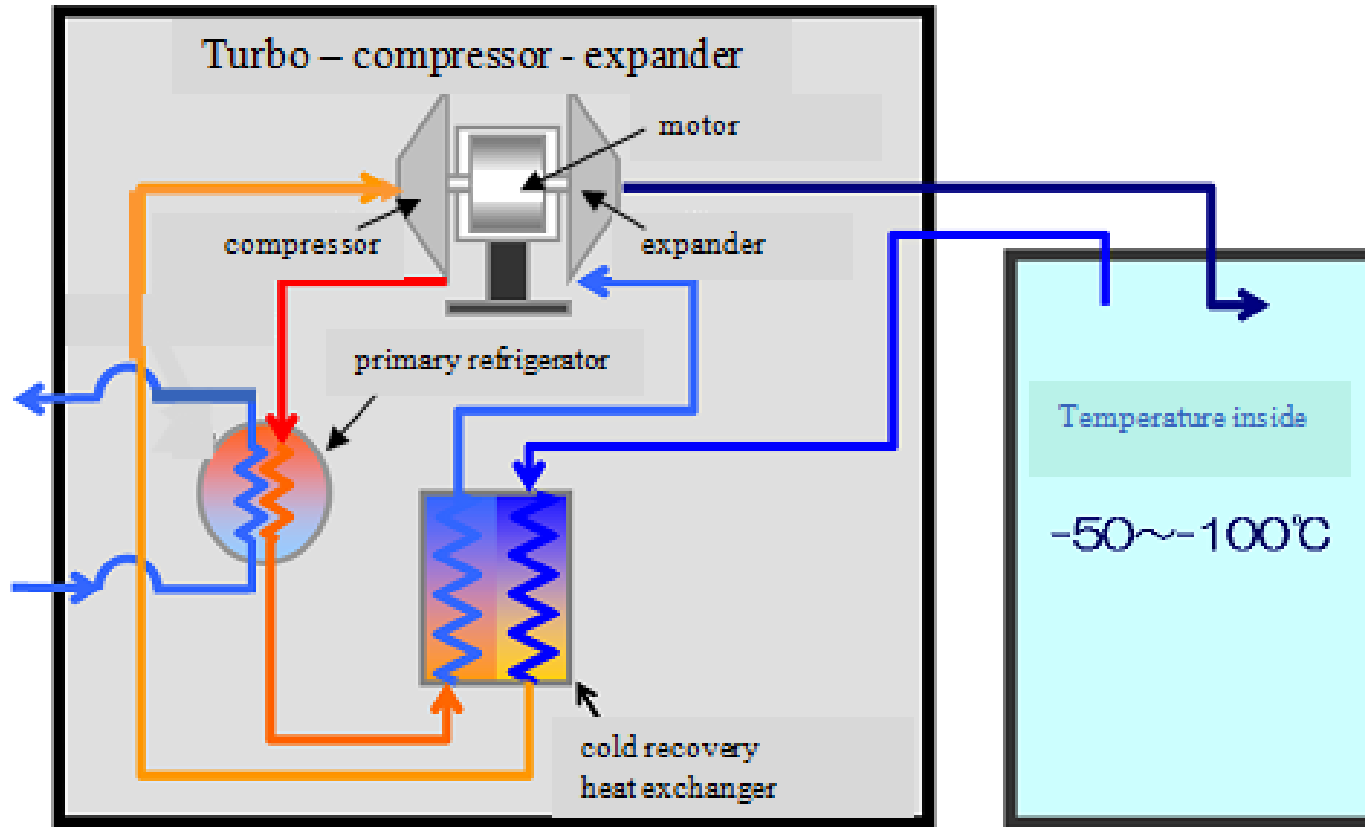
PROCESS CYCLE :
 Adiabatic compression ->
 Heat dissipation
 &
 Adiabatic expansion ->
 Heat absorption
 conducted in GAS phase.



with constant pressure
 change,
 without condensation or
 evaporation

simple system, equipment:
 COMPRESSOR +
 HEAT EXCHANGERS +
 EXPANDER

INTRODUCTION 'PASCAL AIR'



Air – refrigeration system "Pascal Air"

Low temperature system

OUTER VIEW AIR REFRIGERATION SYSTEM



Size:
W3100
L4600
H3100
mm
TRANSPORTABLE

STANDARD SPECIFICATIONS

| REFRIGERANT | AIR | |
|-------------------------------------|-----------|-----|
| REFRIGERATION CAPACITY | 30 | kW |
| COMPRESSOR POWER | 60 | kW |
| TEMPERATURE (refrigerator blow-out) | -60 / -80 | °C |
| MWP | 0.2 | MPa |

Open cycle directly using the air with MWP of 0.2 Mpa.
HP safety regulation n.a.

Air ducts can easily be extended or re-routed when facility re-arrangement is needed.

Refrigerant filling &/recovery n.a.

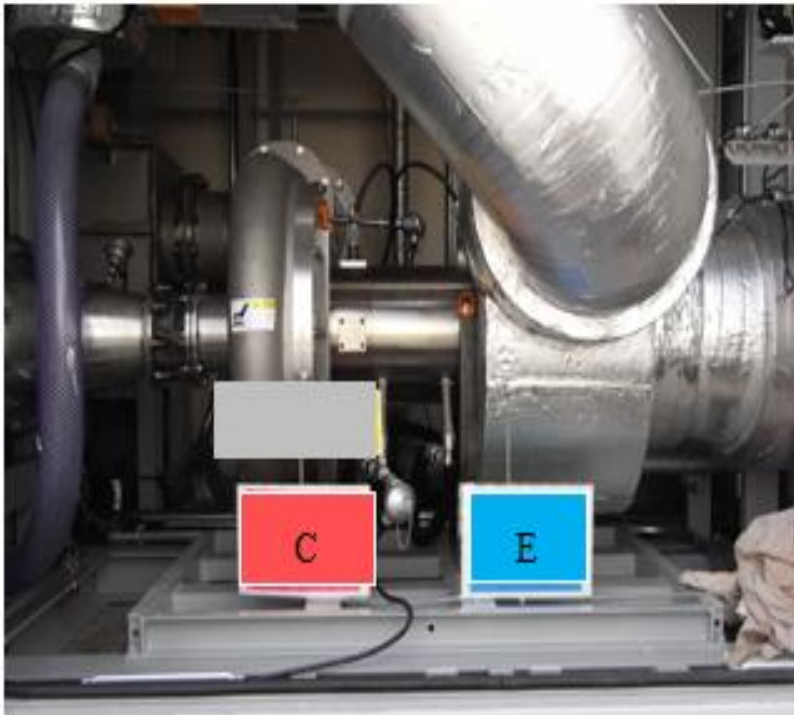
Large-scale construction n.a.

Operating costs reduced.

Maintenance reduced.

STANDARD SPECIFICATIONS

Appearance of turbo-type expander-integrated compressor



Compressor : turbotype

Expander : adiabatic expansion
generates 1/3rd of power
needed for compression

Motor : built-in in center
in coaxial structure

FIELD CASE

Plant :

Yaizu City, Shizuoka Prefecture, Japan

Tuna & bonito fish storage

Nominal capacity 1795tons -50° C

System circulates ultra low temperature air as refrigerant (-80° C)

| | | |
|--------------------------|---------------|------|
| Installation date | December 2008 | Unit |
| refrigerator temperature | -60 | °C |
| total capacity | 150 | kW |
| nr of machines per room | 3 | |
| nr of rooms | 2 | |

INSTALLATION OF PASCAL AIR



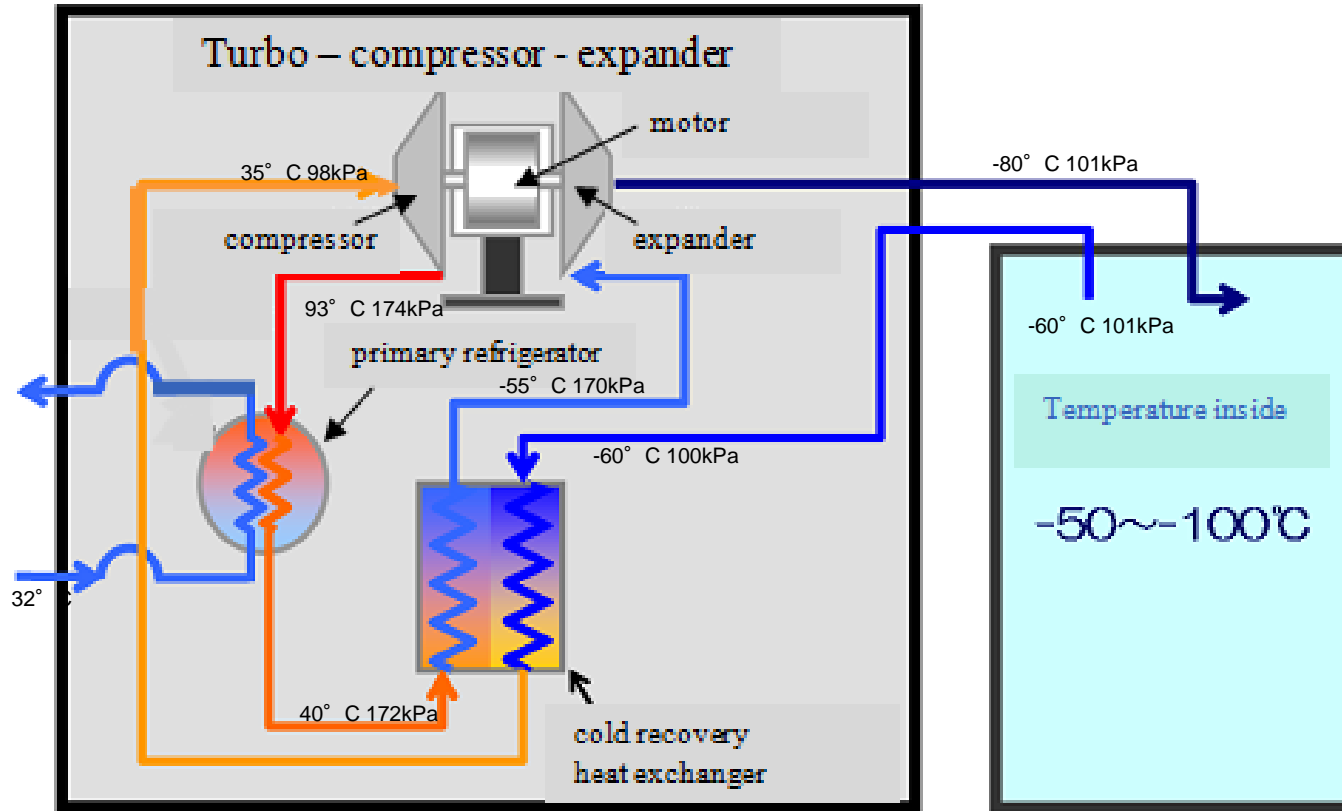
CONVENTIONAL ULTRA-LOW TEMPERATURE REFRIGERATOR



'PASCAL -AIR' ULTRA-LOW TEMPERATURE REFRIGERATOR



PLANT FLOW DIAGRAM



Air – refrigeration system “Pascal Air”

Low temperature system

PLANT OPERATING CONDITIONS

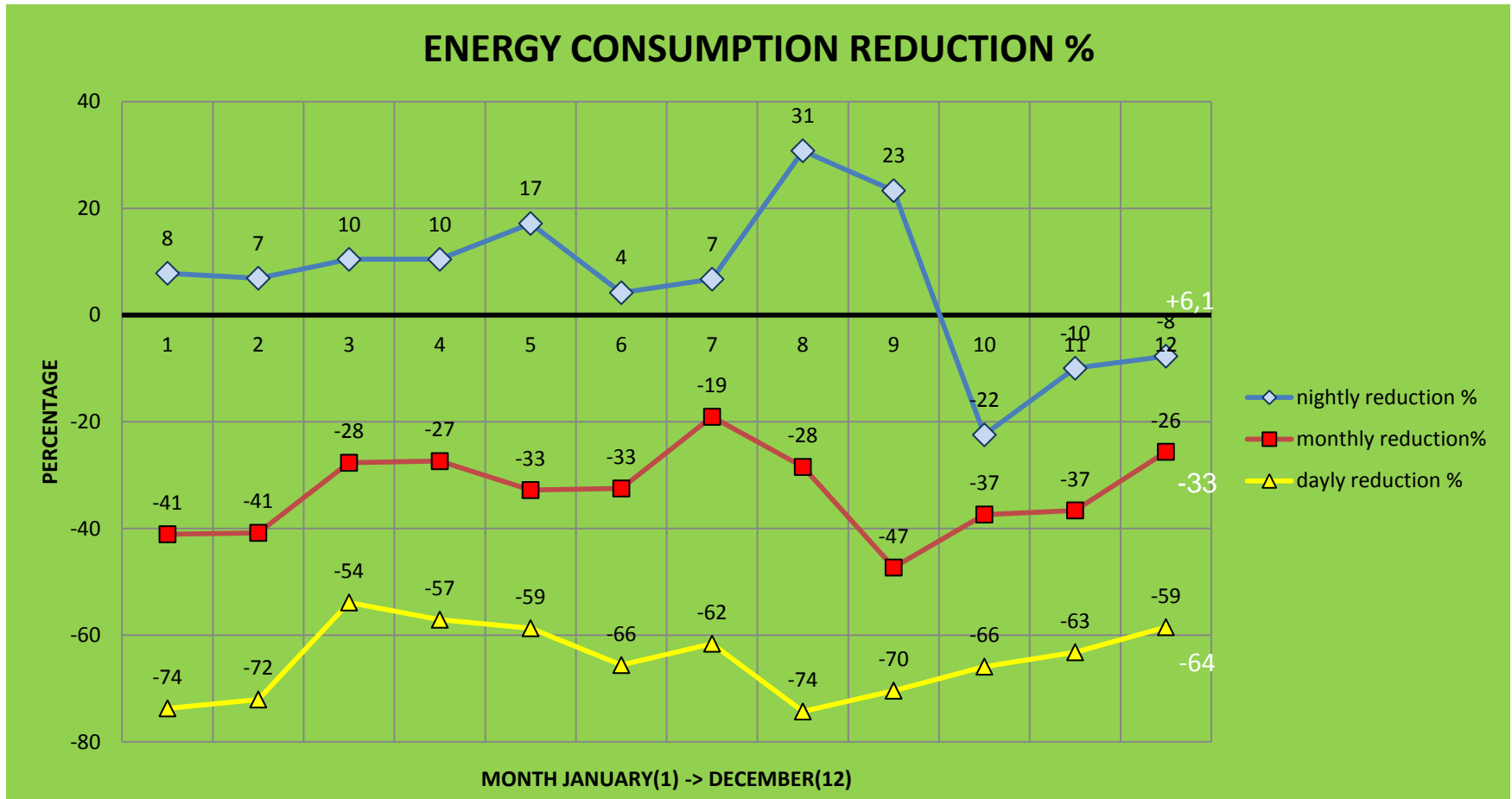
| | | | |
|---------------------------|------------------------------|-----------------|-------|
| | nr 1 | 6667 | hours |
| operating | nr 2 | 5996 | hours |
| hours per | nr 3 | 6069 | hours |
| 8/4/2011 | nr 4 | 6597 | hours |
| | nr 5 | 6173 | hours |
| | nr 6 | 7410 | hours |
| performance data per unit | | | |
| | suction pressure (35°C) | 0,98 | bara |
| | discharge pressure (93°C) | 1,74 | bara |
| | rotation speed (invertor) | 12.000 - 18.000 | rpm |
| | capacity | 30 | kW |
| | power consumption | 72 | kW |
| | air outlet temperature | -80 | °C |
| | refrigerator air temperature | -60 | °C |
| | gain expander | 40 | kW |

PLANT ENERGY CONSUMPTION

TOTAL YEARLY POWER CONSUMPTION (kWh)

| R23/R22 CASCADE SYSTEM | | | PASCAL AIR SYSTEM | | |
|------------------------|---------|---------|-------------------|---------|---------|
| OPERATING REGIME | | | OPERATING REGIME | | |
| DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| 1880000 | 1490000 | 3370000 | 674000 | 1581000 | 2255000 |
| | | | REDUCTION | | |
| | | | -64,1 | 6,1 | -33,1 |

ENERGY SAVINGS



**20° C temperature difference :
Blow-in air <> Low temperature system**

**Reduces the air circulation to 1/10th
compared to conventional cooling(2-3° C)**

**Result :
Cooled products are not dried out
Quality is preserved
Load on workers is reduced**

**COPwise 'PASCAL AIR'
advantage<>conventional system**

**application-field : ultra low t° <-50° C
'blanc area for conventional systems'
Apart category <> conventional systems!**

**Product developed by use of research
results with NEDO in 2003-2005**

(New Energy & Industrial Development Organisation)

TO-DAY APPROX. 10 UNITS OPERATIONAL

“PASCAL AIR” MARKETS

| MARKETS | APPLICATION |
|----------------------------|--|
| INDUSTRIAL REFRIGERATION | Fish (tuna & bonito freezing) Freeze drying Ice cream |
| MARINE/FISH INDUSTRY | Food |
| PHARMACEUTICAL/ MEDICAL | Medical producing process Storage blood samples Organ cooling reacting process |
| FINE CHEMICAL | Manufacturing process for electronic material |
| PETROCHEMICAL | Process gas cooling Condensation Distillation Extraction |
| SEMICONDUCTOR | Condensation process of detergent |
| WASTE DISPOSAL | Recycling Crushing Rubber and plastics |

THANKS FOR YOUR
ATTENTION!

Presented by Jan Boone, MAYEKAWA

MARKET AVAILABILITY

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- 8 production plants



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