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natural refrigerants

Interactive workshops bringing together decision makers from industry and government to change the future of natural refrigerants.

**VII Congress**

**IMPROVING ENERGY EFFICIENCY & REFRIGERATION LATEST TECHNOLOGIES WITH NATURAL REFRIGERANTS**

## FIELD CASE OF "NATURAL 5 REFRIGERANTS" TECHNOLOGY

# MAYEKAWA´S HIGH PRESSURE NH3 HEAT PUMP FOR HOT WATER PRODUCTION.

**19 – 20 . IV 2016. Barcelona, Spain**

MAYEKAWA

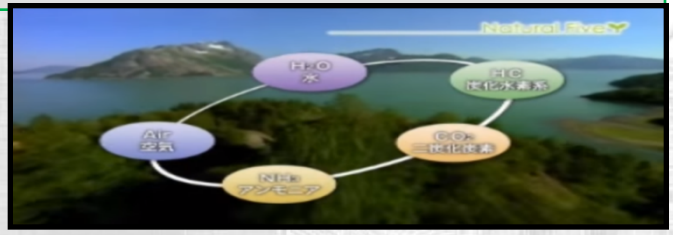
Presented by Pedro Nogal, MAYEKAWA S.L.

# "Natural Five" Refrigerants and Product Solutions

| Refrigerant (Natural Five) | $NH_3$ R-717 | $CO_2$ R-744 | HC Hydrocarbon | $H_2O$ R-718 | Air R-728 |
|---|---|---|---|---|---|
| 90℃ / 60℃ / 10℃ / -15℃ / -25℃ / -40℃ / -50℃ / -60℃ / -100℃ | Utility hot water Heating; Chilled water Ice making | Utility hot water; Chilled water Ice making | Utility hot water Heating HVAC | Heat recovery; Chiller | |
| | Cold storage, Freezer, Fish boat | | | | |
| | Specific Refrigeration needs | | | | |
| | Freezer, Freeze-dry, Super Low temp storage | | Cryogenics | | Cryogenics |
| Notes | ・Conventional system ・National Projects | ・Eco-Cute | ・Nat'l Proj. ・Butane + Propane | ・Nat'l Proj. ・Adsorption ・Heat recovery | ・Nat'l Proj. ・Air-cycle |

NH3 HIGH PRESSURE APPLICATION
TO HEAT RECOVERY FOR
HIGH TEMPERATURE HOT WATER

# FIELD CASE



NH3 HIGH PRESSURE APPLICATION
TO HEAT RECOVERY FOR
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# NATURAL REFRIGERANTS

*+29ºC / +68ºC NH3 flooded system.*
*Hot water +65ºC.*

*In Food Industry.*

*presentation by : Pedro Nogal*

# INTRODUCTION

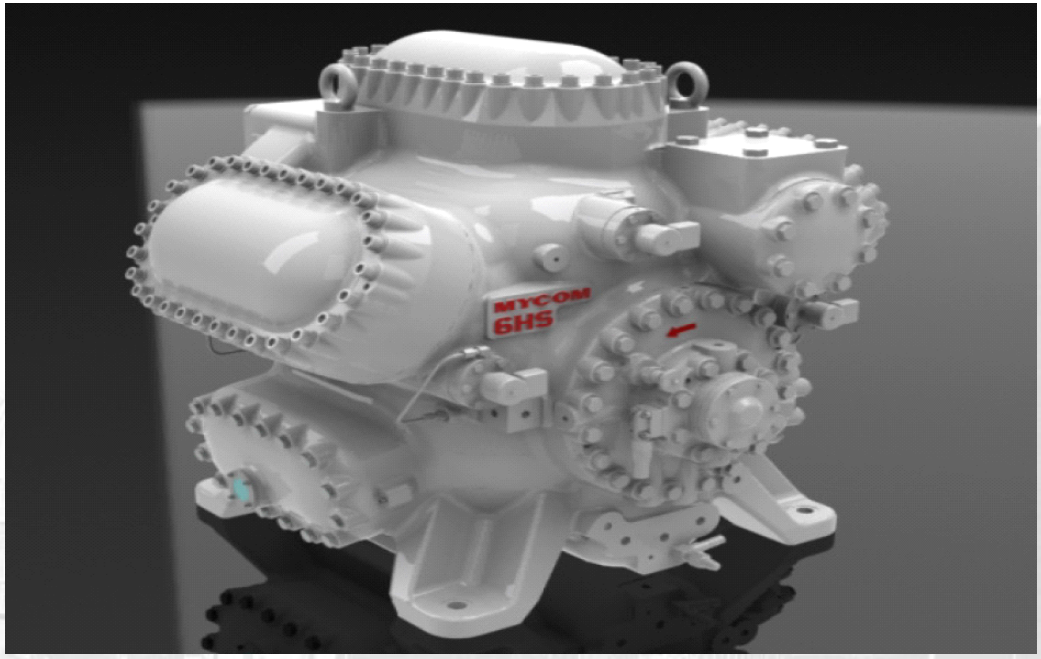
| REQUEST | 333 m3/day of hot water +65ºC | Hot water for production and cleaning process. |
|---|---|---|
| HOT WATER | ~ +14°C | Reduce boiler gas consumption<br>NH3 heat pump (ODP & GWP=0)<br>Tc=+68°C (31,6 bar)<br>Use 'waste heat' <> condensor load |
| NH3 FLOW AVAILABLE | 0,915 kg/s | |
| SELECTION | NH3 | +29/+68°C<br>NH3 : flooded system with HS compressor unit. |

# INSTALLED COMPRESSOR:

| MODEL | N6HS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAPACITY | [kW] | 1021,4 | 983,2 | 944,7 | 906,1 | 867,4 | 828,5 | 789,5 | 750,4 | 711,1 | 671,8 | 632,4 | 592,9 |
| CAPACITY | [TR] | 290,4 | 279,6 | 268,6 | 257,7 | 246,6 | 235,6 | 224,5 | 213,4 | 202,2 | 191 | 179,8 | 168,6 |
| ABSORBED POWER | [kW] | 200,4 | 191,7 | 183,1 | 174,6 | 166,2 | 157,9 | 149,6 | 141,5 | 133,4 | 125,5 | 117,6 | 109,9 |
| | | | | | | | | | | | | | |
| SPEED | [min-1] | 1300 | 1250 | 1200 | 1150 | 1100 | 1050 | 1000 | 950 | 900 | 850 | 800 | 750 |
| LOAD | [%] | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONDENSING TEMP. | [degC] | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| EVAPORATIVE TEMP. | [degC] | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| | | | | | | | | | | | | | |
| COP cooling | [-] | 5,1 | 5,13 | 5,16 | 5,19 | 5,22 | 5,25 | 5,28 | 5,3 | 5,33 | 5,35 | 5,37 | 5,39 |
| HEATING CAPACITY | [kW] | 1206,2 | 1159,4 | 1113,1 | 1066,3 | 1019,4 | 972,6 | 925,7 | 878,9 | 831,4 | 784,6 | 737,7 | 690,9 |
| COP heating | [-] | 6,02 | 6,05 | 6,08 | 6,11 | 6,13 | 6,16 | 6,19 | 6,21 | 6,23 | 6,25 | 6,27 | 6,29 |
| Water Supply from +14/+65 | [m3/h] | 20,34 | 19,55 | 18,77 | 17,98 | 17,19 | 16,4 | 15,61 | 14,82 | 14,02 | 13,23 | 12,44 | 11,65 |

## NH3 HIGH PRESSURE APPLICATION TO HEAT RECOVERY FOR HIGH TEMPERATURE HOT WATER

# N6HS 66 bar

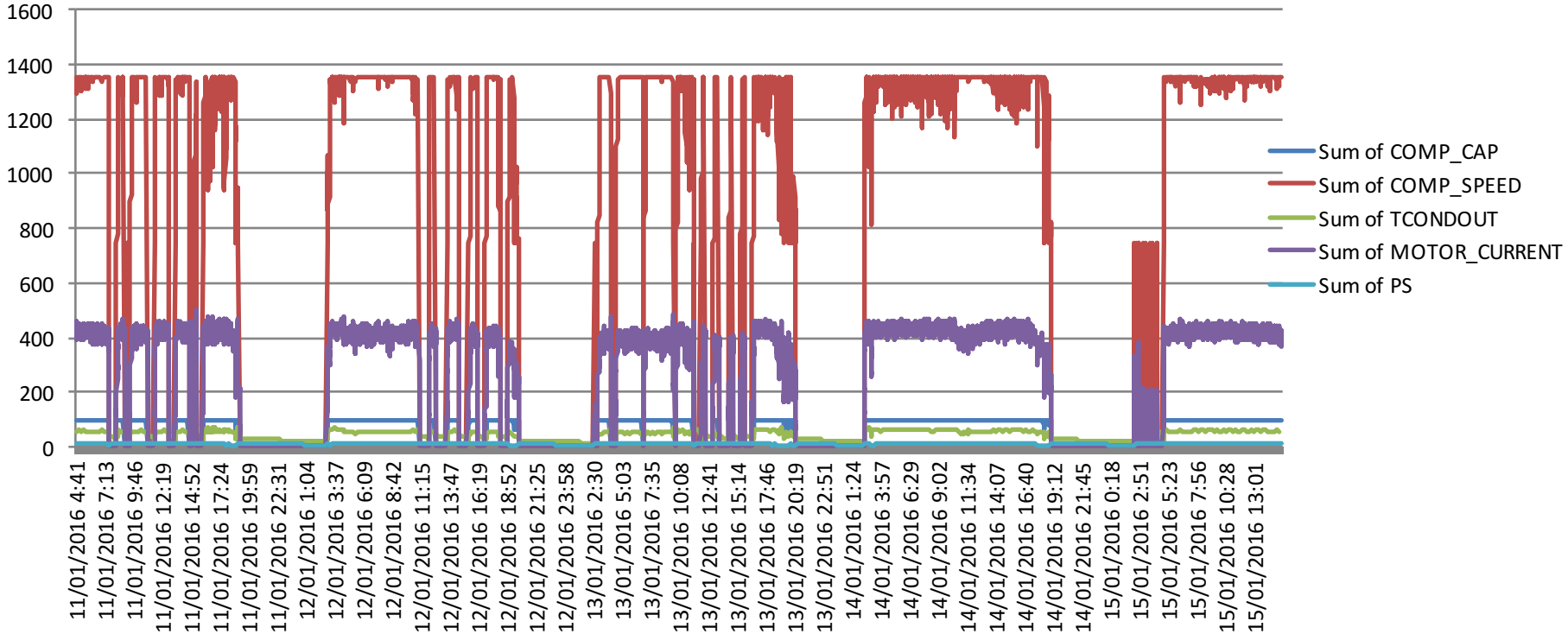



| Item | Limit value | |
|---|---|---|
| Maximum discharge pressure | 6.0 | MPa |
| Minimum discharge pressure | 1.0 | MPa |
| Maximum suction pressure | 2.5 | MPa |
| Maximum differential pressure (top and bottom) | 4.0 | MPa |
| Maximum oil supply pressure | Ps + 0.4 | MPa |
| Minimum oil supply pressure | Ps + 0.15 | MPa |
| Minimum suction temperature | −60 | °C |
| Maximum discharge temperature | 160 | °C |
| Maximum oil supply temperature | 70 | °C |
| Minimum oil supply temperature | 30 | °C |
| Maximum speed | 1500 | $min^{-1}$ |
| Minimum speed | 750 | $min^{-1}$ |
| Maximum water supply temperature | 50 | °C |
| Minimum water supply temperature | 15 | °C |
| Maximum cooling water pressure | 0.5 | MPa |
| Minimum cooling water pressure | 0.2 | MPa |

# SAVING ENERGY ESTIMATION

| | Cleaning | Production | Total | | inlet | outlet | heating | Flow | Boiler | Gas | Unit Price | | Flow | Power | Electricity | Unit Price | | | Merit | 518 | €/day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hour | | M3 Hour | | | ℃ | ℃ | kW | m3/h | kW | €/kW | € | | m3/h | kW | €/kW | € | m3 | | Work | 260 | days/Year |
| 1:00 | 14 | | 14 | | 14 | 65 | 830 | 14,0 | 922 | 0,035 | 32,3 | | 20,3 | 200,4 | 0,075 | 15,0 | 6,3 | | Merit | 134.765 | €/Year |
| 2:00 | 14 | | 14 | | 14 | 65 | 830 | 14,0 | 922 | 0,035 | 32,3 | | 20,3 | 200,4 | 0,075 | 15,0 | 12,6 | | | | |
| 3:00 | 14 | 11 | 25 | | 14 | 65 | 1.483 | 25,0 | 1.647 | 0,035 | 57,7 | | 20,3 | 200,4 | 0,075 | 15,0 | 7,9 | | | | |
| 4:00 | 14 | 11 | 25 | | 14 | 65 | 1.483 | 25,0 | 1.647 | 0,035 | 57,7 | | 20,3 | 200,4 | 0,075 | 15,0 | 3,2 | | | | |
| 5:00 | 14 | 11 | 25 | | 14 | 65 | 1.483 | 25,0 | 1.647 | 0,035 | 57,7 | | 20,3 | 200,4 | 0,075 | 15,0 | -1,5 | | | | |
| 6:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 20,3 | 200,4 | 0,075 | 15,0 | 7,8 | | | | |
| 7:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 20,3 | 200,4 | 0,075 | 15,0 | 17,1 | | | | |
| 8:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 20,3 | 200,4 | 0,075 | 15,0 | 26,4 | | | | |
| 9:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 19,6 | 191,7 | 0,075 | 14,4 | 35,0 | | | | |
| 10:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 19,6 | 191,7 | 0,075 | 14,4 | 43,6 | | | | |
| 11:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 0 | 0 | 0,075 | 0,0 | 32,6 | | | | |
| 12:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 0 | 0 | 0,075 | 0,0 | 21,6 | | | | |
| 13:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 0 | 0 | 0,075 | 0,0 | 10,6 | | | | |
| 14:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 0 | 0 | 0,075 | 0,0 | -0,4 | | | | |
| 15:00 | | 11 | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 19,6 | 191,7 | 0,075 | 14,4 | 8,2 | | | | |
| 16:00 | 14 | | 14 | | 14 | 65 | 830 | 14,0 | 922 | 0,035 | 32,3 | | 19,6 | 191,7 | 0,075 | 14,4 | 13,8 | | | | |
| 17:00 | 14 | | 14 | | 14 | 65 | 830 | 14,0 | 922 | 0,035 | 32,3 | | 19,6 | 191,7 | 0,075 | 14,4 | 19,4 | | | | |
| 18:00 | 11 | | 11 | | 14 | 65 | 652 | 11,0 | 725 | 0,035 | 25,4 | | 19,6 | 191,7 | 0,075 | 14,4 | 28,0 | | | | |
| 19:00 | 9 | | 9 | | 14 | 65 | 534 | 9,0 | 593 | 0,035 | 20,8 | | 19,6 | 191,7 | 0,075 | 14,4 | 38,6 | | | | |
| 20:00 | 7 | | 7 | | 14 | 65 | 415 | 7,0 | 461 | 0,035 | 16,1 | | 19,6 | 191,7 | 0,075 | 14,4 | 51,2 | | | | |
| 21:00 | 7 | | 7 | | 14 | 65 | 415 | 7,0 | 461 | 0,035 | 16,1 | | 19,6 | 191,7 | 0,075 | 14,4 | 63,8 | | | | |
| 22:00 | 22 | | 22 | | 14 | 65 | 1.305 | 22,0 | 1.450 | 0,035 | 50,7 | | 0 | 0 | 0,075 | 0,0 | 41,8 | | | | |
| 23:00 | 22 | | 22 | | 14 | 65 | 1.305 | 22,0 | 1.450 | 0,035 | 50,7 | | 0 | 0 | 0,075 | 0,0 | 19,8 | | | | |
| 0:00 | 14 | | 14 | | 14 | 65 | 830 | 14,0 | 922 | 0,035 | 32,3 | | 0 | 0 | 0,075 | 0,0 | 5,8 | | | | |
| | 190 | 143 | 333 | m3/day | | | | 333,0 | 21.942 | | 768,0 | €/day | 338,8 | 3328,5 | | 249,6 | €/day | | | | |
| | | | | | | | | | | | 199.671 | €/Year | | | | 64.906 | €/Year | | | | |

# RUNNING OPERATION DATA



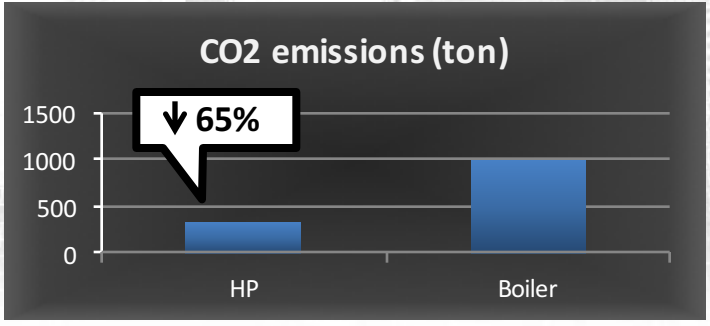
# OPERATION SAVINGS

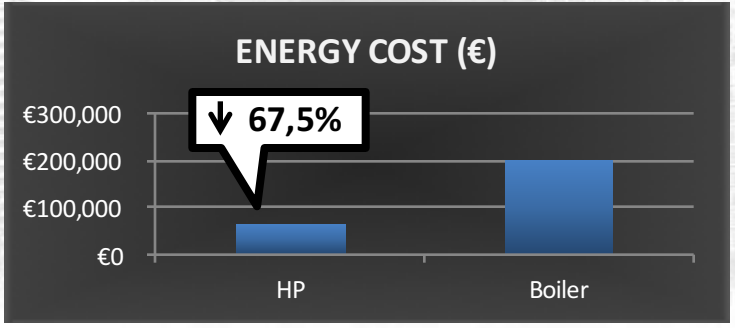
# HOT WATER HEAT PUMP

333 m3/day from +14ºC to +65ºC = 19.747 kWh/day



| | HEAT PUMP | BOILER |
|---|---|---|
| COP (Coefficient of Performance) | 6,02 | 0,90 |
| Energy consumption (kWh/day) | 3.328,5 KWh/day | 21.942 Kwh/day |
| Annual energy consumption (KWh/260days) | 865.410 kWh/year | 5.704.920 kWh/year<br>490.535 m3 Natural Gas |
| Energy prices | 0,075 €/kWh | 0,035 €/kWh |
| Energy costs | 64.906 € | 199.672 € |
| CO2 emissions | 346 ton | 1.006 ton |



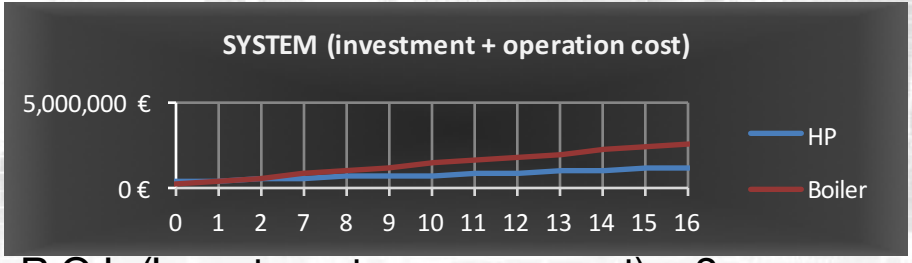
# OPERATION SAVINGS

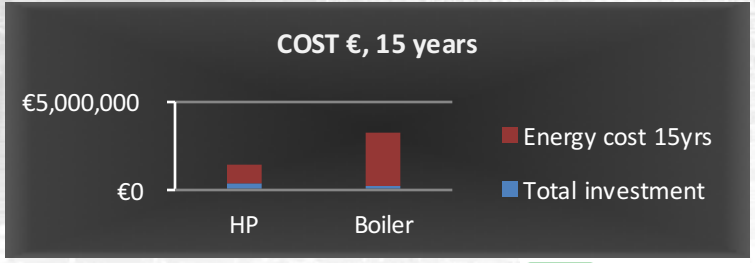
# HOT WATER HEAT PUMP

333 m3/day from +14°C to +65°C = 19.747 kWh/day



| | HEAT PUMP | BOILER | SAVINGS |
|---|---|---|---|
| Energy costs/year | 64.906 € | 199.672 € | 134.766 € |
| CO2 emissions/year | 346 ton | 1.006 ton | 660 ton |
| Invesment | 350.000 € (HP unit + installation + water and NH3 circuits + water buffer tank 100m3) | 175.000 € (Boiler + installation + water and G.N. Circuits + water buffer tank 30m3 and N.G.) | -175.000 € |
| Energy cost 15yrs | 973.590 € | 2.995.080 € | 2.021.490 € |
| Total cost 15yrs | 1.323.590 € | 3.170.080 € | 1.846.490 € |



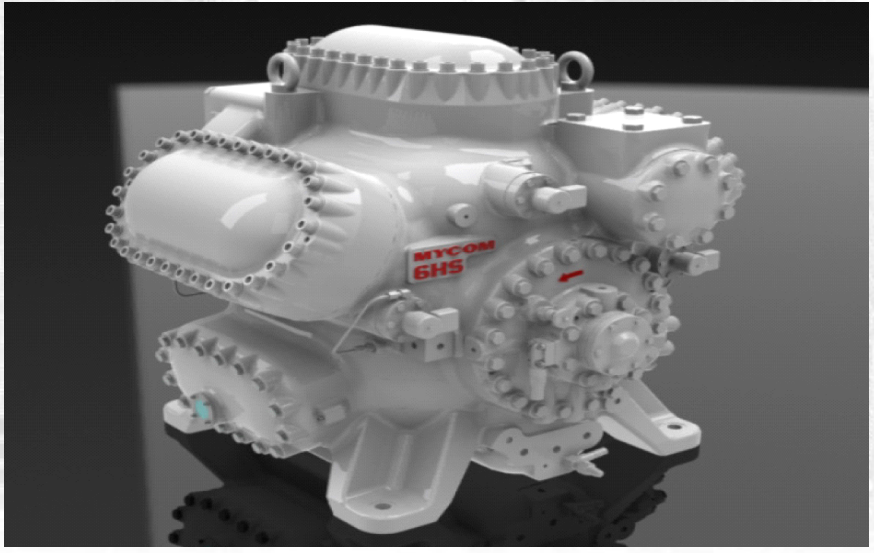




R.O.I. (Investment + energy cost) < 2 years

# TRAINING

**Product: Organized by Mayekawa to the contractors.**

**System: Organized to Contractors, with Mayekawa-support, to the users.**



# INSTALLATION + COMMISIONING + OPERATION

| Installation | Contractor + Mycom support |
|---|---|
| Commisioning (monitoring) | Contractor + Mycom support |
| Finetuning regulation/operation (monitoring) | Stability & long lifetime<br>Machine logbook |
| Reference registration (monitoring) | Future evaluations (site) |
| Event registration (monitoring) | For every action (site &/ remote) |
| Operation registration (monitoring) | Regular basis (site &/ remote) |

# SERVICE & MAINTENANCE

| Daily checks | Qualified personnel (operators, Contractor service persons) |
|---|---|
| Routine checks | idem |
| Main service (overhauls) | **Rotation Speed (N) Range (min-1) Overhaul Period**<br>Checking HS Manual. |
| Lubrication oil | Regular check<br>Preventive analysis<br>Preventive particle filtration |
| Registration | For every service & maintenance activity |

# Special thank-word :

Mr. Carlos Tomás
Mr. David Tomás

Frío Industrial

CONTRACTOR
ISOFRED S.L.
Alcoletge, Lleida

ATMO sphere
faster to market
natural refrigerants

¡ Thank you very much for your kindly attention !

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