



**A case study:
R290 chillers and R600a
heat pumps replacing a
R22 system in a hospital**

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The Aarhus University Hospital Skejby is expanding the site and needed new chillers to replace out of date R22 chillers:

- ◆ The existing R22 chillers were scattered out on different places
- ◆ The leak rate was increasing and becoming expensive
- ◆ In Denmark the maximum HFC charge allowed is 10 kg/circuit
- ◆ For the chillers was chosen R290 and for the heat pumps R600a
- ◆ CO₂ heat pumps were looked at as an option but were not chosen
- ◆ The current site is first step in a major expansion
- ◆ The staff at Aarhus University Hospital Skejby took ownership of the project which helped the whole project materialize
- ◆ The project was realized as part of getting out and modernizing the existing plant
- ◆ The current site is 160,000m² and the expansion coming is 190,000m²

Aarhus University Hospital Skejby



Google Street view



Efficiency Analysis

All systems are tested in a end of line test prior to shipments. Efficiency was obtained by optimization after some further tests. The obtained efficiency is accepted by the customer prior to shipment:

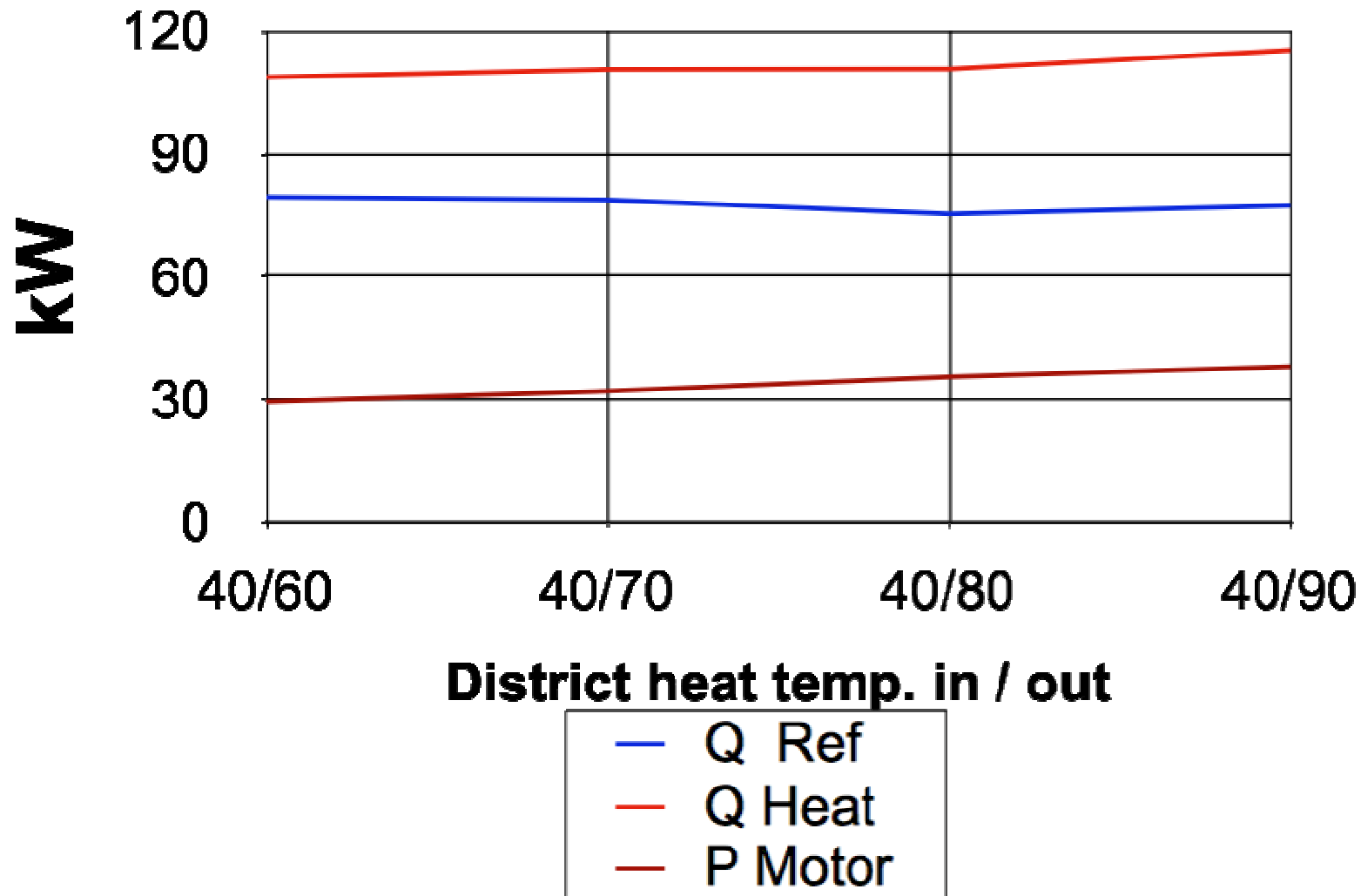
- ◆ The chillers used are a standard product producing cooling at 9/15 dgr. C 35% propylene glycol
- ◆ The heat pumps are producing hot water at 80 dgr. C during the winter and 70 dgr. C in the summer period. The heat pumps deliver the required cooling capacity in the winter time
- ◆ The challenge was to optimize the system allowing the use of semi-hermetic screw compressors
- ◆ The efficiency was evaluated against other options and was qualified by being the best overall solution for the project.

Capacities



Measured in test

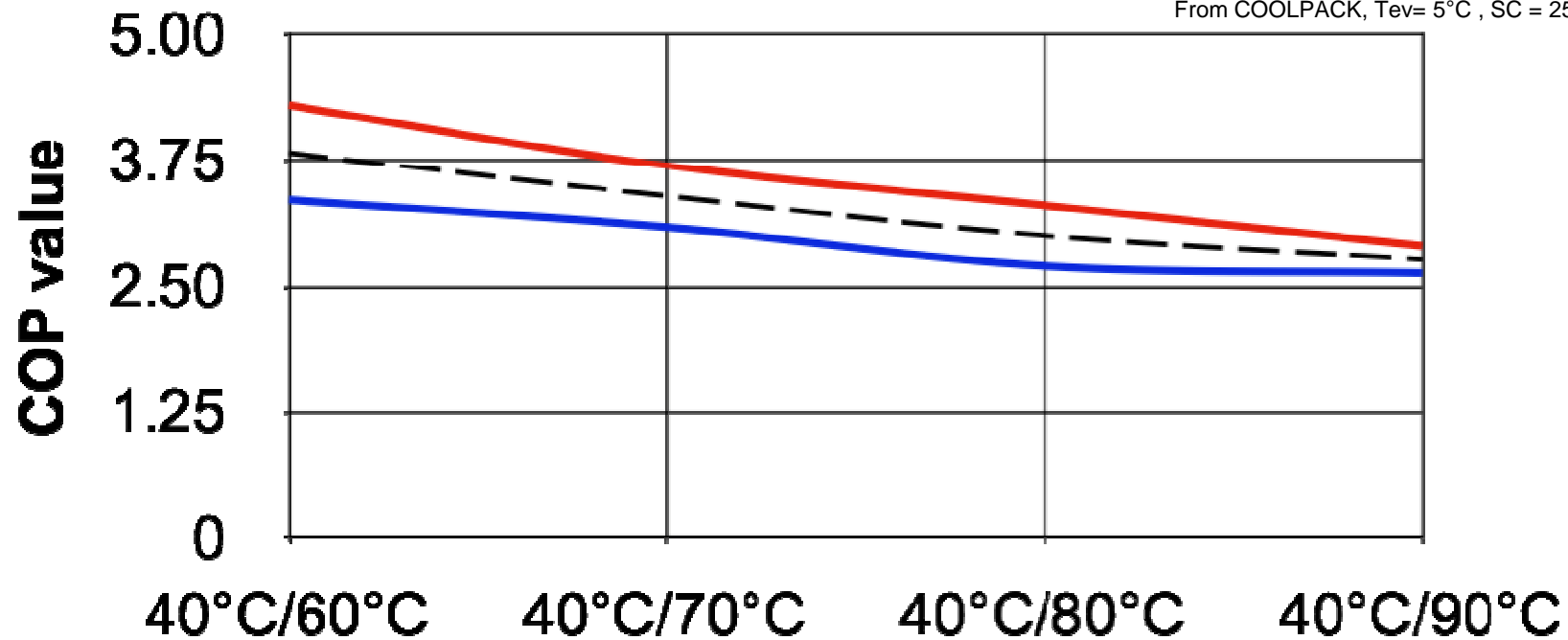
Heat Pump Capacity



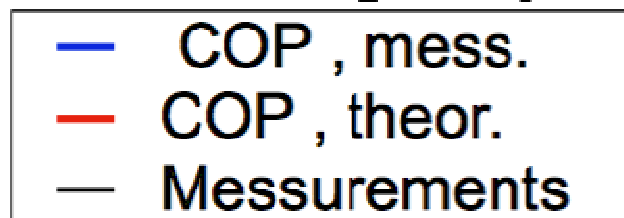
COP
Measured and theoretical

COP heat pump

COP
From test rig at Johnson Controls
From COOLPACK, $T_{ev} = 5^{\circ}\text{C}$, $SC = 25^{\circ}\text{C}$



District heating temp set



Difference between theoretical and measured values in first tests

- The heat loss on the warm side was greater than expected
- There may be an internal leak in the compressor or elsewhere in the system
- Oil in the evaporator
- A increase in the COP = 10% is achievable

Cost considerations

As the refrigerant had to be natural there were only very few solutions to choose from. The efficiency became one of the main drivers. The project was won in open competition with other solutions:

- ◆ Price level found by public tender
- ◆ Due to charge size restrictions, fear of further restrictions and HFC tax these systems were not evaluated to be a sustainable solution
- ◆ HC refrigerants are much cheaper than HFC refrigerants which are also falling in short in the market due to limited supplies
- ◆ The efficiency has created a good basis for further developments together with the suppliers. The heat pumps were originally a development project which was accepted by the customer
- ◆ The replaced R22 systems contained about 2400 kg in total
- ◆ The higher efficiency of the new systems has partially helped shortening the payback period

Barriers and Solutions

The competing technology was based on R744 but an analysis proved R600a to be a better solution for this specific customer:

- ◆ HC refrigerants are widely used in Denmark also by other suppliers
- ◆ The authorities and fire brigade are used to the type of equipment and regulations are in place and understood
- ◆ No safety problems, legislative barriers etc
- ◆ Short and long term cost differences

Lessons learned

Very important issues around the control strategy and philosophy; what is the primary function of a heat pump? Heating or cooling? It is important that both sides of the system are working under optimal conditions:

- ◆ It is important to make clear design requirements already in the tender phase. Guidelines have to be developed and distributed.
- ◆ Calculation tools need to be developed and also decision charts/tools to find out if the cooling and heating requirements coincide (same time) or if you need to buffer either side of the system.
- ◆ R600a is sensitive to pressure loss on the low pressure side the lower the temperature becomes

Future plans

The R290 chiller production is now going in to industrial production. The heat pumps will undergo further optimisation during industrialisation:

- ◆ New plants using chillers for heating and cooling are currently in operation and production and the performance is promising
- ◆ Strong commitment from the market
- ◆ Careful consideration on requirements on both sides
- ◆ Carefully consideration on loads over the year
- ◆ Engage with local authorities as early as possible especially if ground source/sink is used
- ◆ Consider further expansions as early as possible

Our Action Plan

Our plans include HC chillers based on R290 and in the future chiller/heat pumps based on R600a along side other chillers and heat pumps also based on natural refrigerant R717:

1. Our actions

- ◆ We are launching the HC chillers as a global product from end of 2011 and the beginning of 2012 on an industrial scale
- ◆ Existing NH₃ chillers and heat pumps (up to 72 C°) are promoted for larger and industrial applications with good success
- ◆ In 2012 the current range of chillers and heat pumps on NH₃ and R290 will be extended with heat pumps based on open and semi-hermetic screw compressors reaching leaving temperatures 80 and 90 C°

Our Action Plan

- 2. Needed action from political side
 - ◆ Smoke signals are no good; we prefer clear messages and dates
 - ◆ The technology is ready, we know what training is needed, safety requirements are clear in standards and regulations
 - ◆ Clear policy guidelines with timelines that allow adoption of the technology in all areas. Some areas need further development to allow the safe use of natural refrigerants in all market segments
 - ◆ The market requires clear messages and regulations, costs can be overcome as the price for the alternative (HFC) is surging due to the raw material cost, end users are eager to get going with the new and exciting technology
 - ◆ Training must be made available for all players with focus on safety for the individuals as well as the public



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natural refrigerants

11-12 October 2011 in Brussels

Thank your
attention

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