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INTERNATIONAL INSTITUTE OF REFRIGERATION

Experimental Analysis of Various Refrigerant Circuit Component Combinations for Low Charge Propane Heat Pumps

Hannes Fugmann, Timo Methler, Clemens Dankwerth, Lukas Joos, Katharina Morawietz, Lena Schnabel

Fraunhofer Institute for Solar Energy ISE, Germany

Paper 171

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01

Motivation

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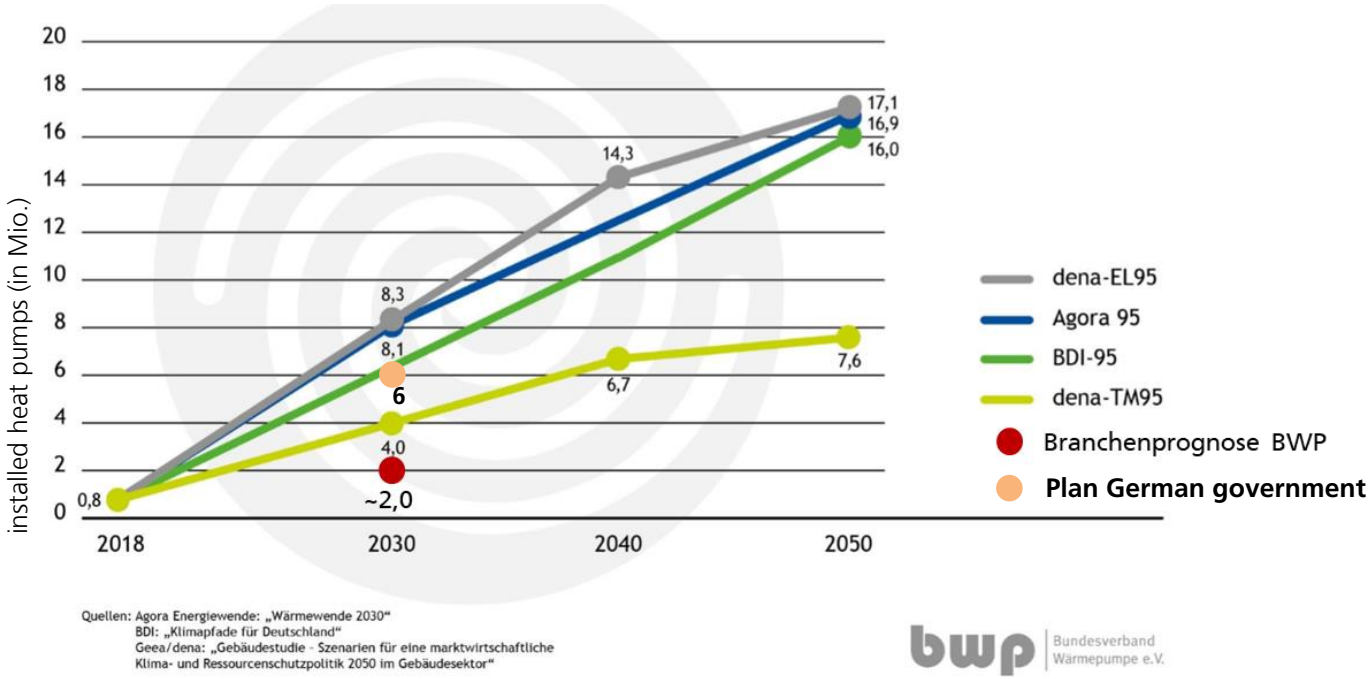
Motivation

- Heat pumps are the central heating technology for a climate-friendly future and decarbonized heating supply
- The market share has to be increased drastically in order to reach the needed reductions in CO2 emissions
- New refrigerant solutions are needed due to F-Gas-Regulation
- 150g of refrigerant propane are set as regulatory limit for safe indoor installations
  - Safety concepts are non-standardized and costly



Targets for installed heat pumps in Germany

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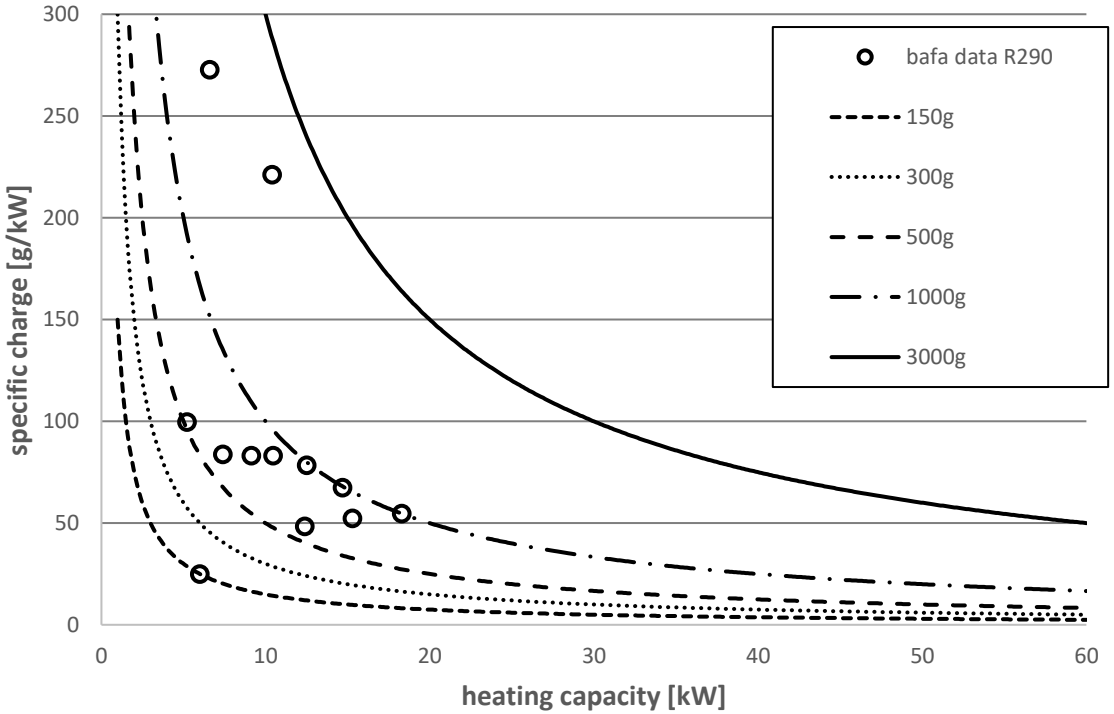
Motivation

Status quo refrigerant charge

- Market available brine-to-water heat pump systems use 50-100 g/kW of refrigerant charge
- 150 g of refrigerant for 10 kW heating capacity corresponds to ~15 g/kW

Goals of the project LC150

- Use of propane (R290) as refrigerant
- Providing a heating capacity between 4-12 kW
- Use of market available components only
- Brine to water heat pump
- Measure and simulate various refrigerant circuits



BAFA data from 2021 for brine to water heat pumps with R290.

LC150: R&D at Fraunhofer ISE with Steering Committee (definition of requirements, receipt of results and access to IPs)

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02

Set up of Prototypes

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Set up of Prototypes

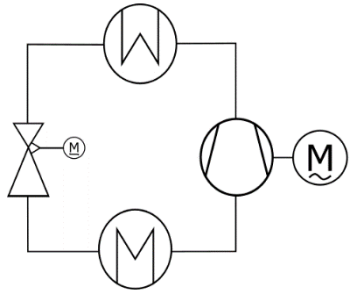
Components

Variety of components
- in single component testing and
- in refrigerant circuit tests

Condenser 1
- 36 Plates
- medium height
- medium width
- Dimple

Condenser 2
- 46 Plates
- small height
- small width
- Fishbone

refrigerant circuit



Compressor 1
- 25-30 ccm
- Scroll
- 400ml oil

Compressor 2
- 25-30 ccm
- Rotary
- 200ml oil

Evaporator 1
- 20 Plates
- Larger height
- Large width
- Dimple

Evaporator 2
- 40 Plates
- medium height
- medium width
- Dimple

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Set up of Prototypes

Refrigerants Circuits

Four refrigerant circuits for showing details

Prototype	Condenser	Evaporator	Compressor	Pipe_d.-outer DL/LL/2pL/SL [mm]	Pipe-length DL/LL/2pL/SL [mm]
RC81	Condenser 1	Evaporator 1	Compressor 1	12/12/12/16	480/190/160/900
RC82	Condenser 2	Evaporator 1	Compressor 2	12/12/12/12	810/200/200/810
RC89	Condenser 2	Evaporator 1	Compressor 2	12/12/12/18	810/200/200/810
RC86	Condenser 1	Evaporator 2	Compressor 1	12/10/12/16	500/150/150/320

Measurement Points

Charge [g]	Super heat [K]	Source Temp [°C]	Sink Temp [°C]	Rpm [%]
0 – 300	5/10/15	-7/0/10	24/27/30/34/ 35/45/55/65	10/40/70/100

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03

Measurement Results

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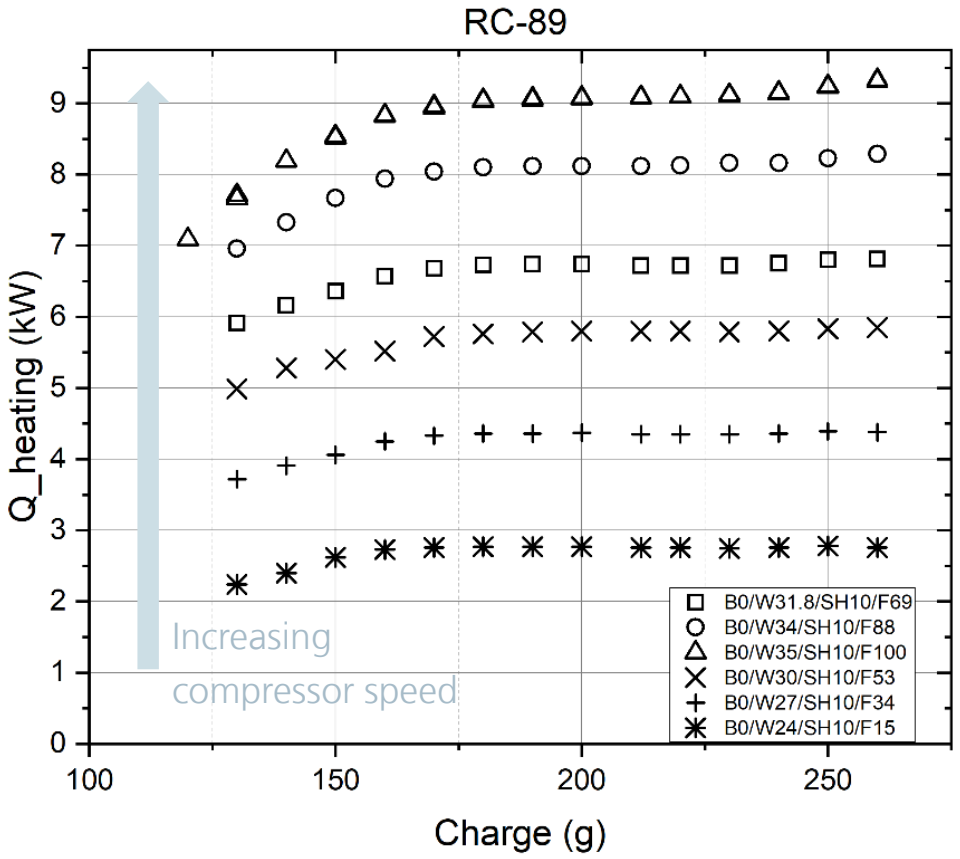
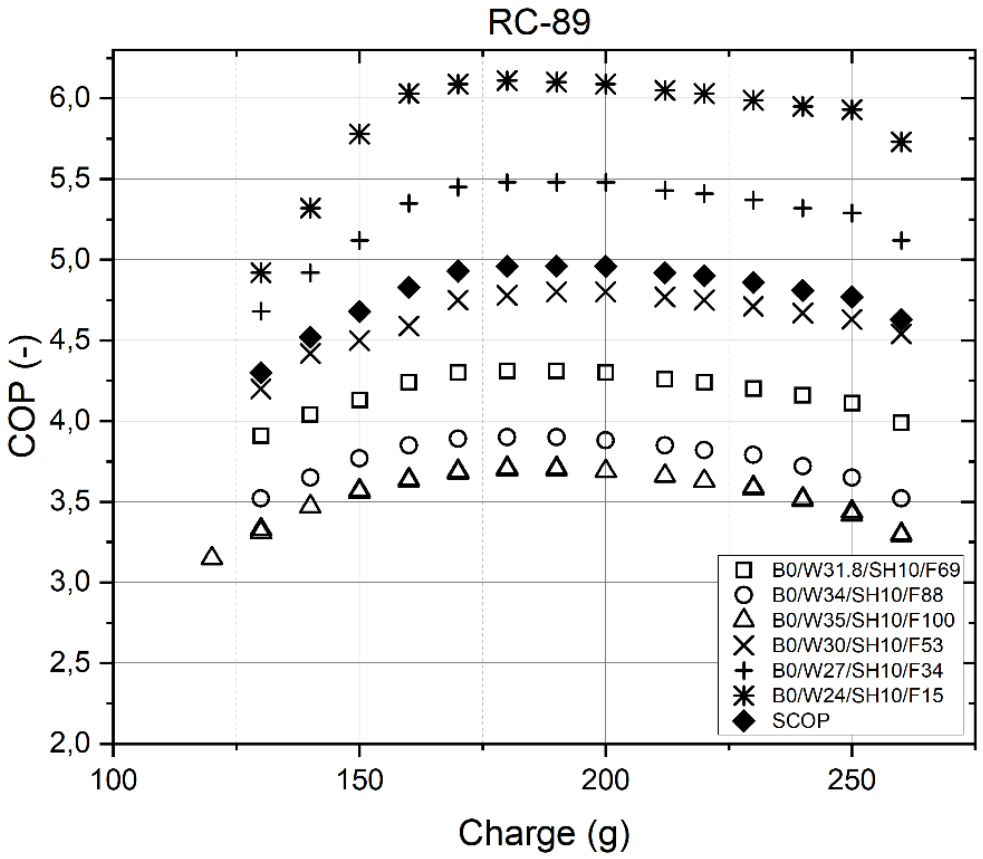
Set up of Prototypes

SCOP operation points





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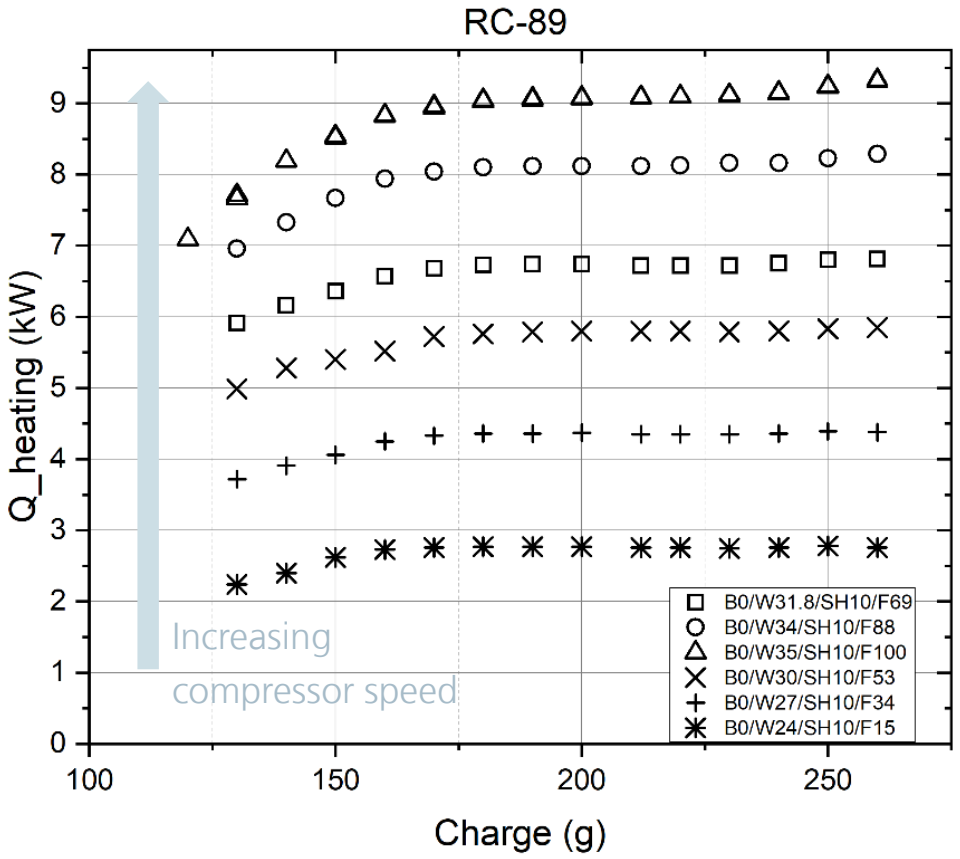
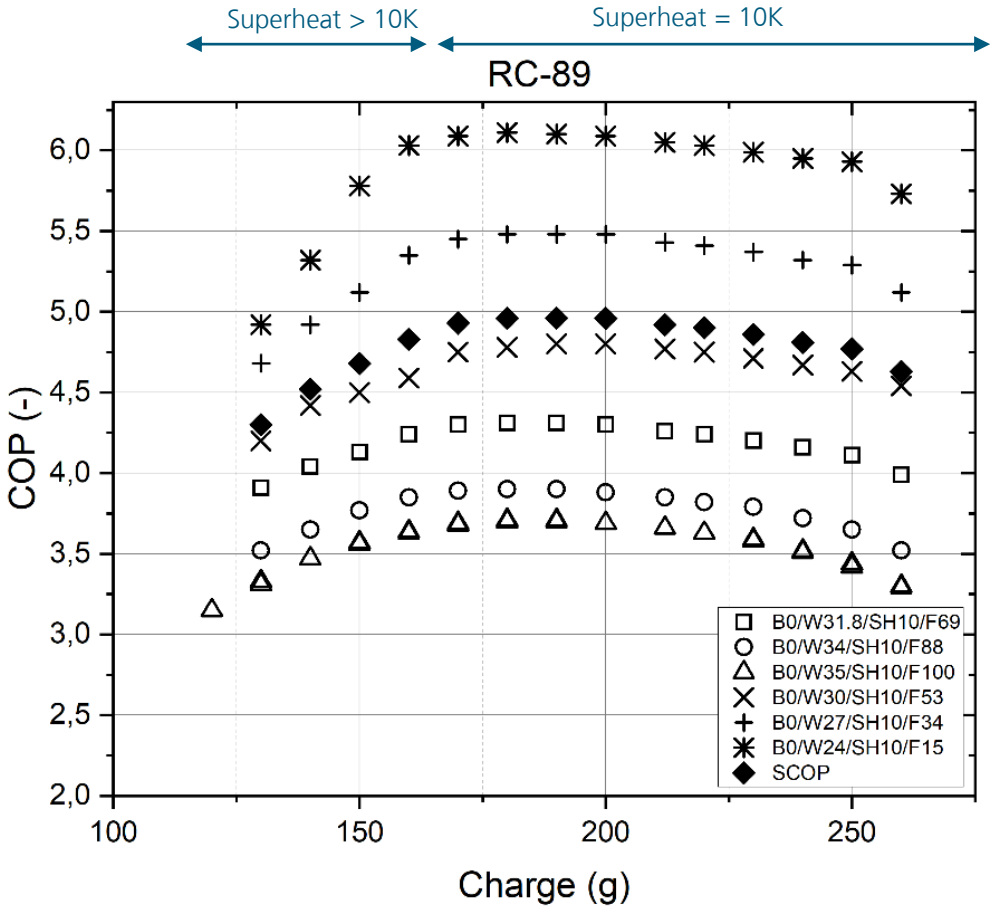
Set up of Prototypes

SCOP operation points





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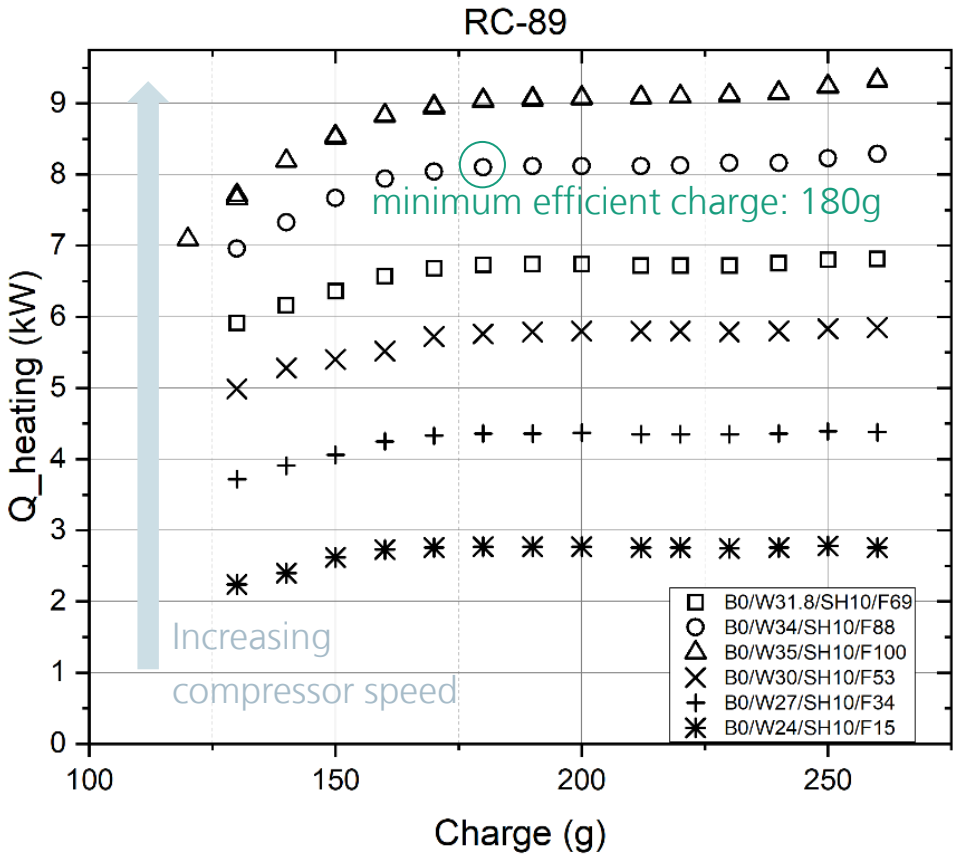
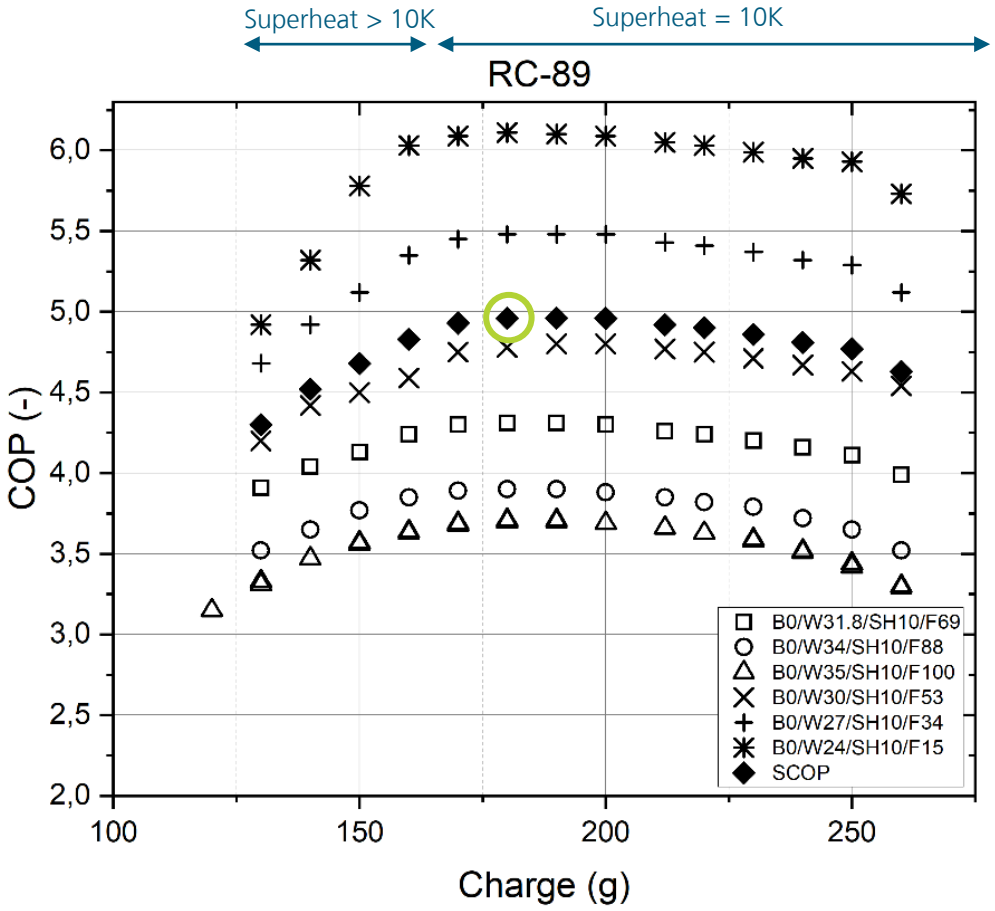
Set up of Prototypes

SCOP operation points





In short

- SCOP: 5
- Maximum heating capacity: 9kW
- Refrigerant charge: 180g

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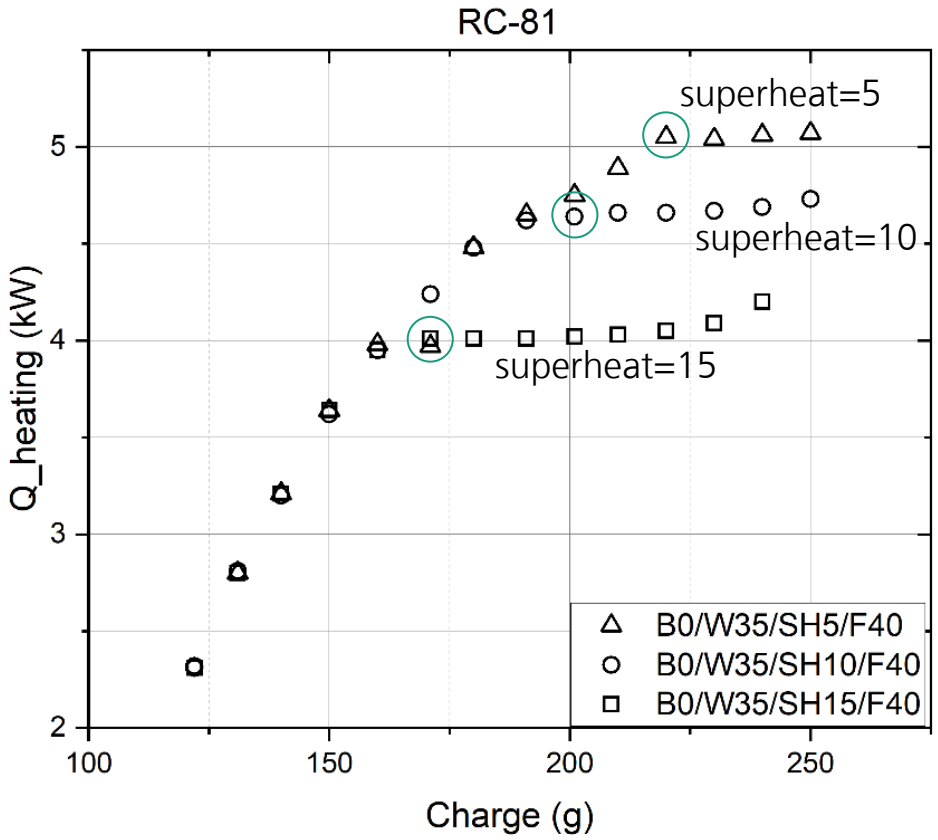
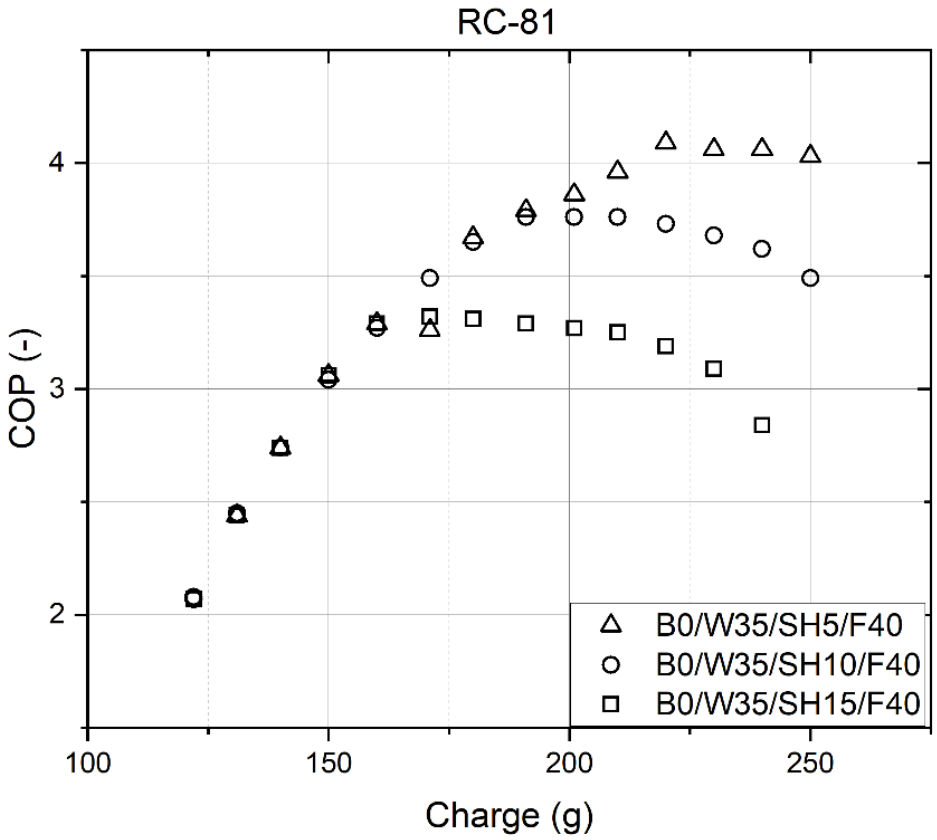
Measurement Results

Variation of super heat





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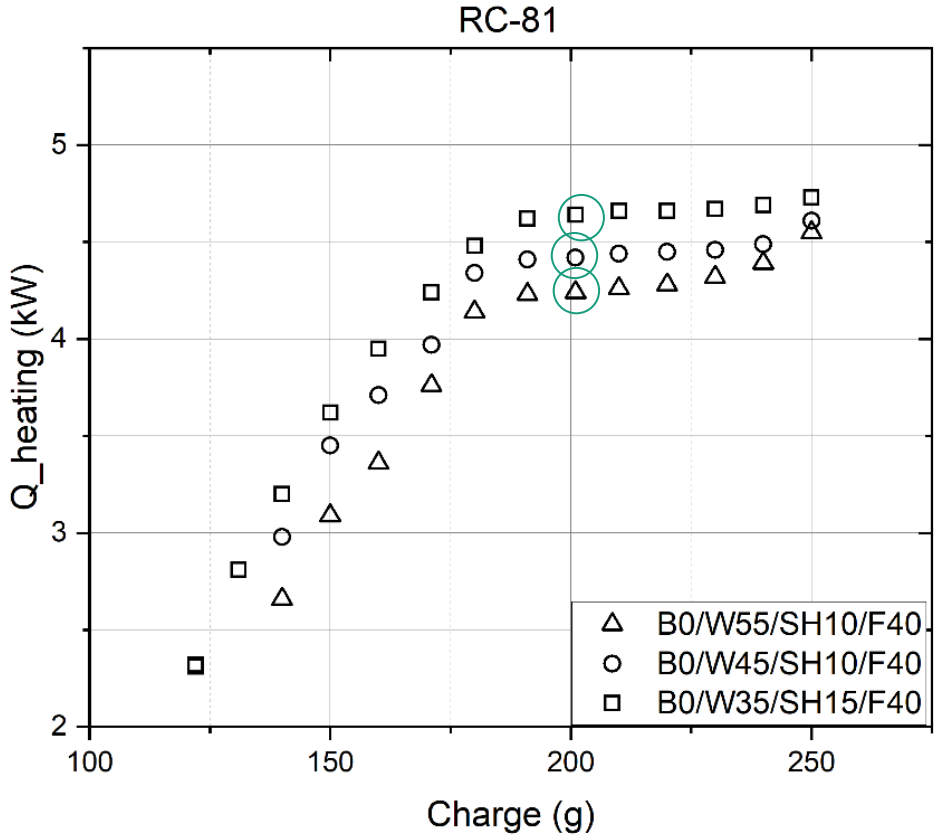
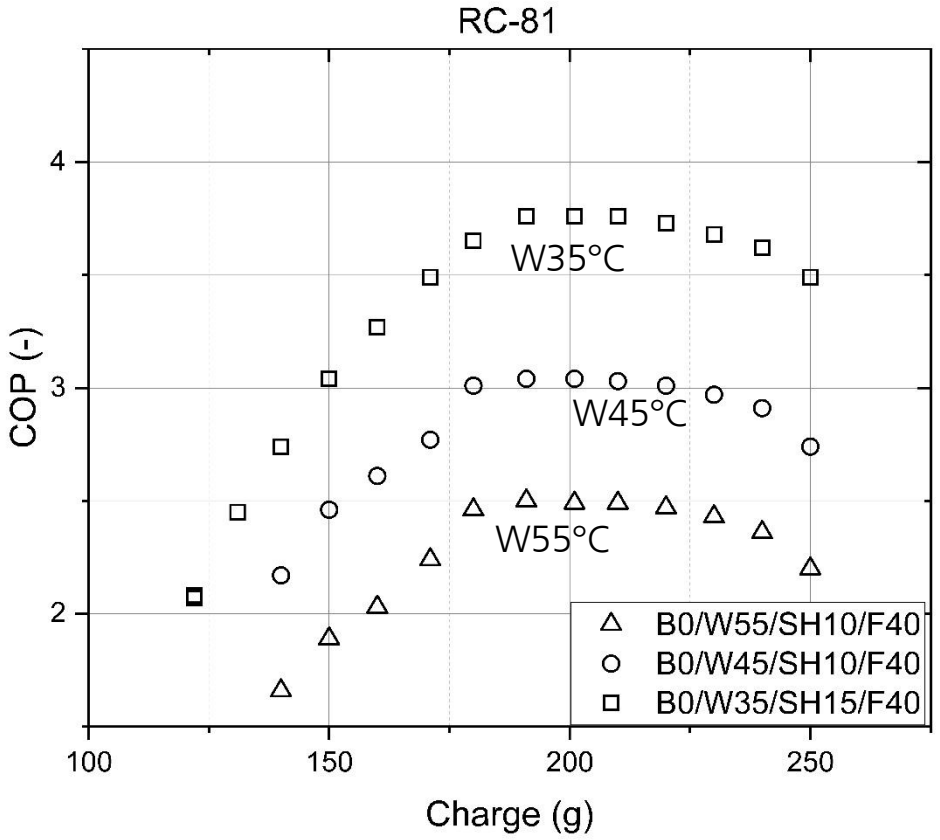
Measurement Results

Variation of the sink temperature





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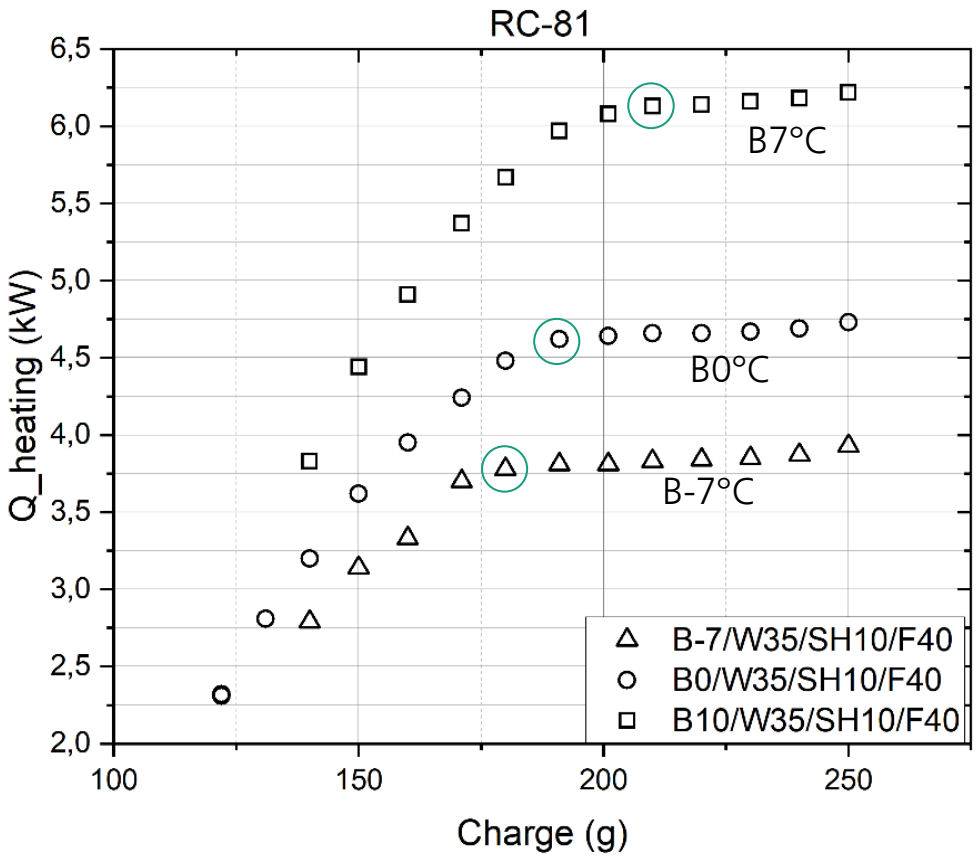
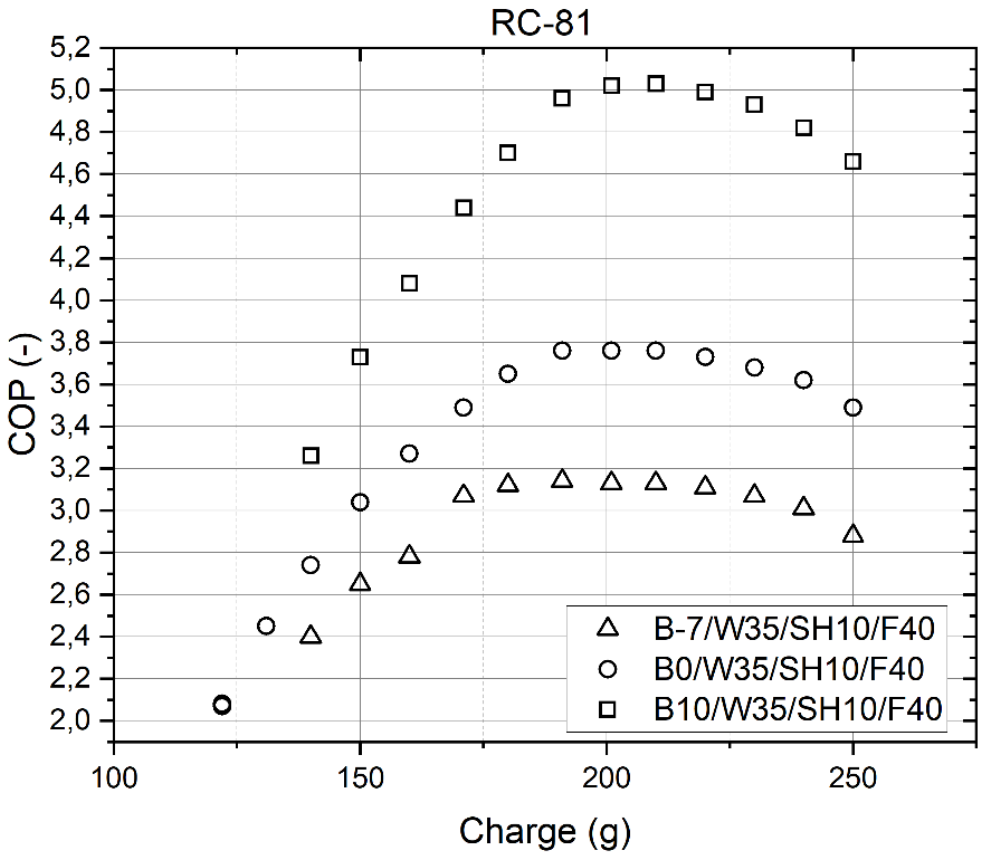
Measurement Results

Variation of the source temperature





source temperature: -7°C to +10°C

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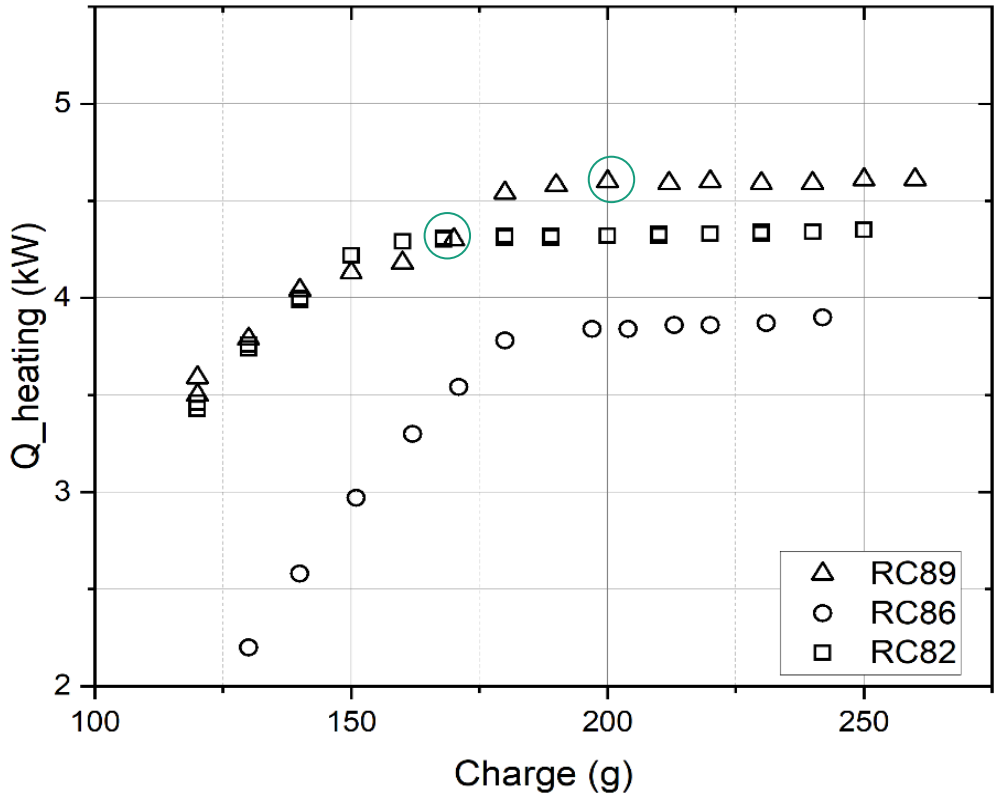
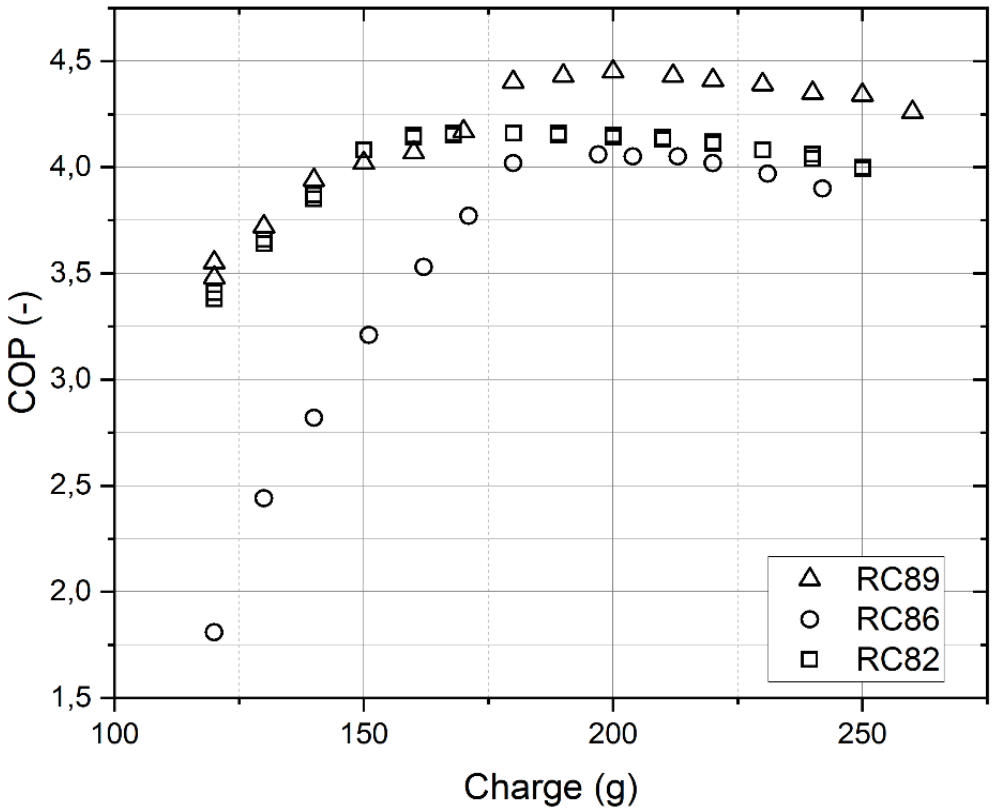
Measurement Results

Comparison of different refrigerant circuits





Comparison at 40% compressor speed

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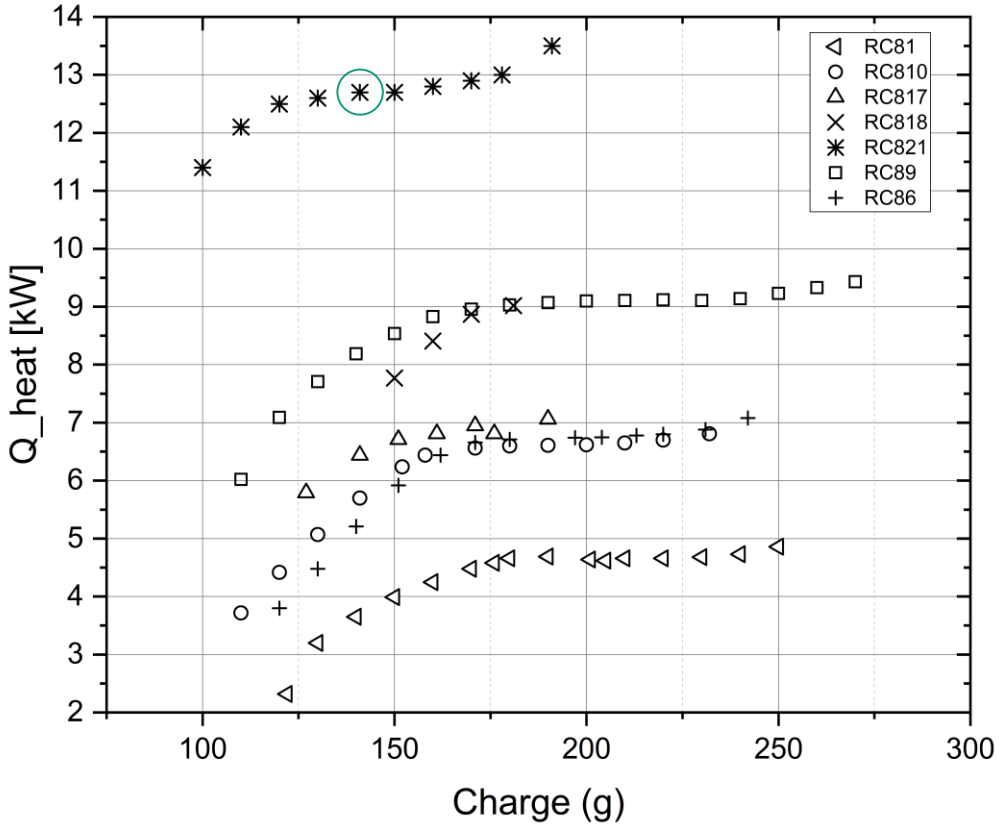
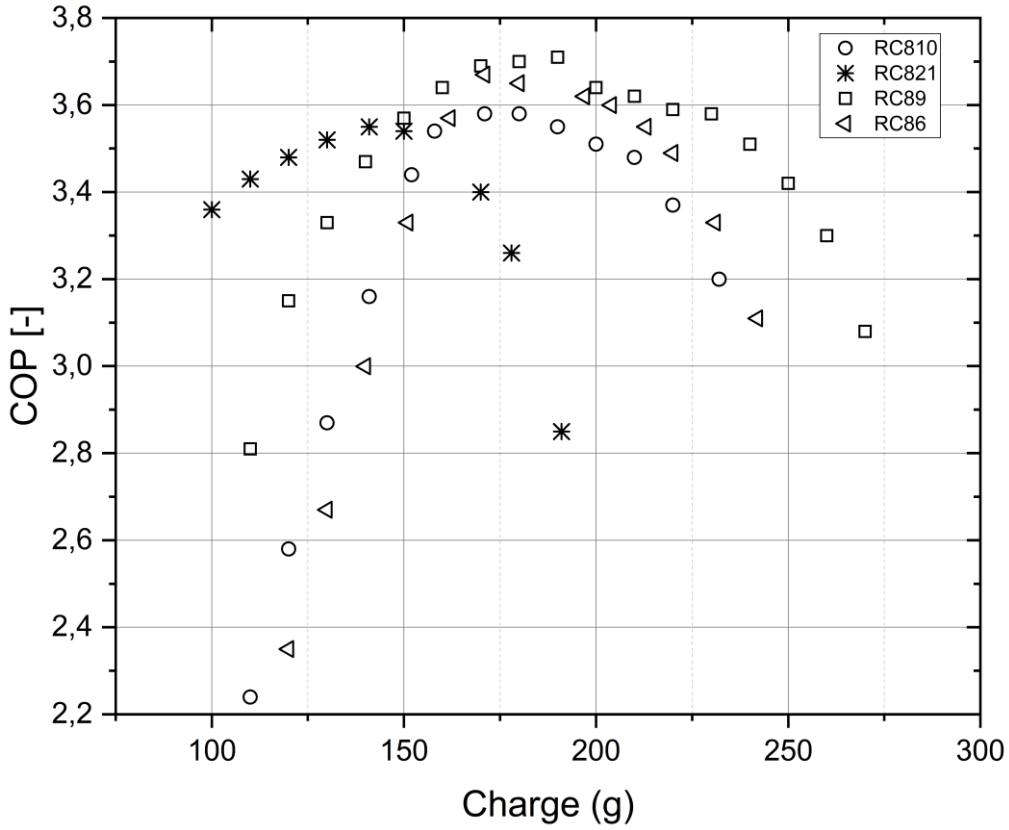
Measurement Results

Comparison of different refrigerant circuits – new circuits





Comparison at 100% compressor speed, B0/W35/SH10

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Conclusion and Outlook

Efficient COP

- SCOP of 5 with a minimum efficient charge of 180 g and a maximum heating capacity of 9 kW realized (RC-89)
- specific charge of 20 g/kW
- reduction of charge to 150 g results in a SCOP decrease to 4.7

Efficient Charge

- SCOP of 4,7 with a minimum efficient charge of 140 g and a maximum heating capacity of 12,5 kW realized (RC-821)
- specific charge of 12 g/kW

Outlook

- More than 20 refrigerant circuits will be measured with more than 30 different components
- Every component will be implemented in the simulation tool IMST-ART in cooperation with University of Valencia to design new refrigerant circuits

» **Indoor installed heat pumps with refrigerant R290 are possible with todays components. Let's do the next steps to the market «**

Lena Schnabel,
LC150 Project Manager

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Thank you …

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Timo Methler

Clemens Dankwerth

Lena Schnabel & Lukas Joos

Katharina Morawietz

Hannes Fugmann | Fraunhofer ISE | Germany

hannes.fugmann@ise.fraunhofer.de