

IEA HPP Annex 28 (2002-2005)

Test Procedure and Seasonal Performance Calculation for Residential Heat Pumps with Combined Space and DHW Heating

Integrated CO₂ Heat Pumps

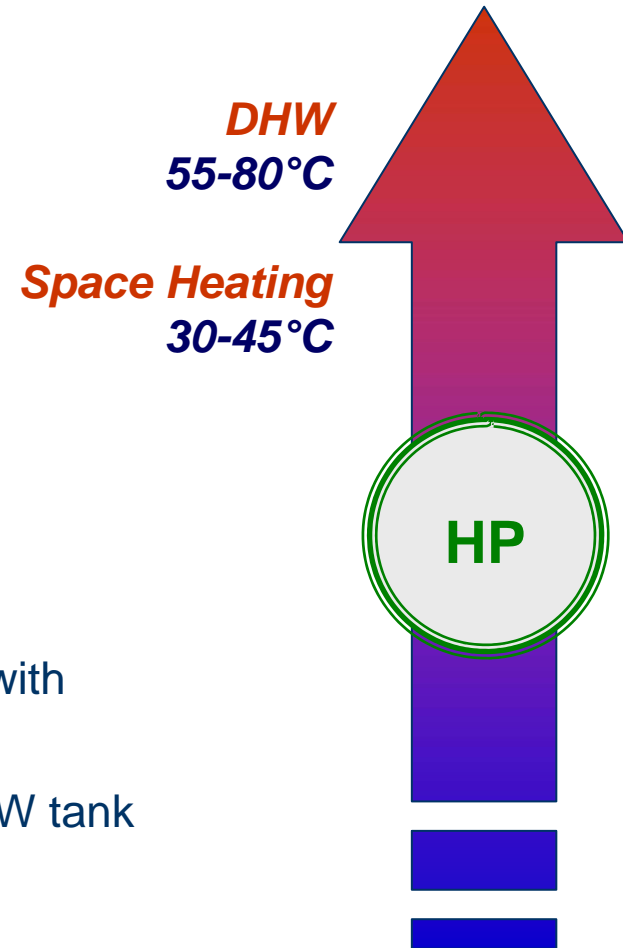


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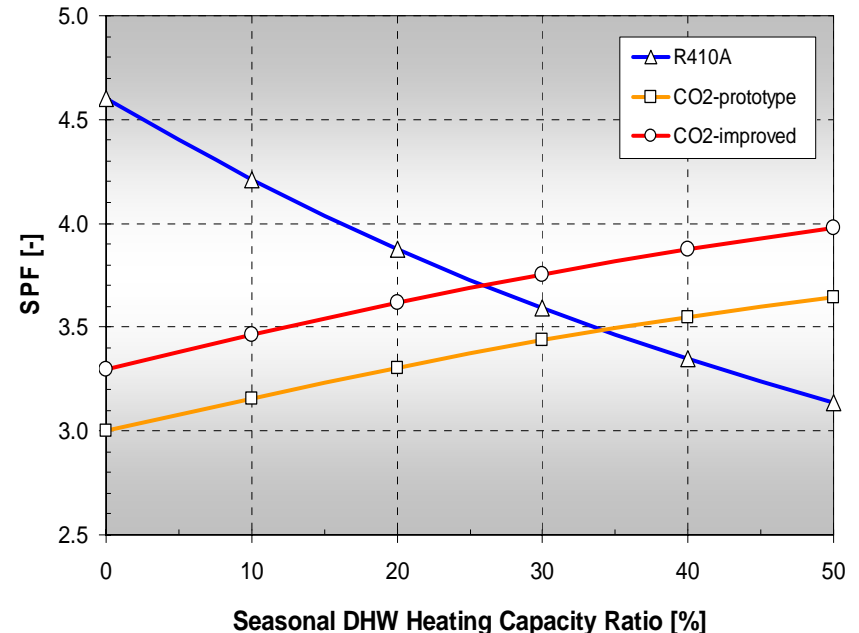
Outline of presentation

- Purpose of new standards and SPF calculation methods
- The transcritical heat pump process
- Classification and possible design of integrated CO₂ heat pumps
 - External gas cooler units – single-shell DHW tank
 - External gas cooler unit – single-shell DHW tank with heat exchanger(s)
 - Integral design for gas cooler and single-shell DHW tank
- Testing – important boundary conditions



Purpose of New Test Standards and SPF Calculation Methods

- Enable fair comparison of integrated CO₂ heat pumps
 - Ensure that the test reflects real heat pump performance
- Enable fair comparison of integrated CO₂ heat pumps with systems using HFC and HC working fluids
 - Different performance characteristics
 - Different system designs
 - Different operating conditions



Heat pumps with CO₂ and HFC/HC have reversed COP characteristics

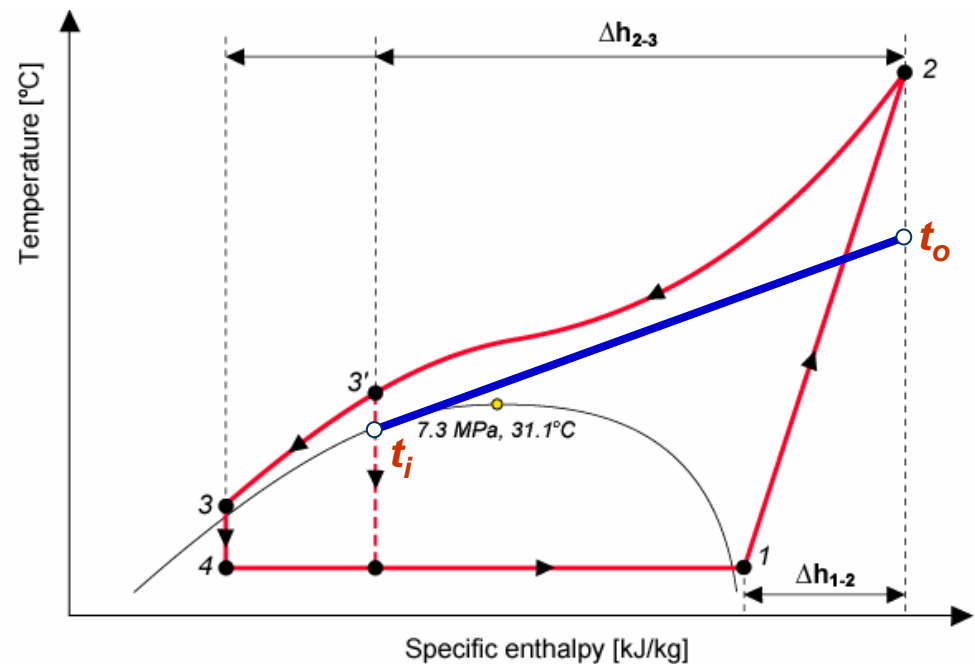
The Transcritical CO₂ Heat Pump Process

■ Characteristic properties

- Evaporation at sub-critical pressure
- Heat rejection at super-critical pressure and decreasing CO₂ temperature

■ COP depends on

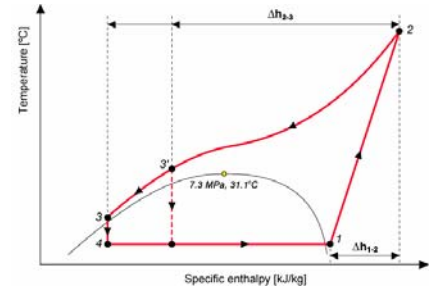
- Heat source temperature
- Inlet temperature t_i for the secondary fluid in the GC
- Set-point temperature for the secondary fluid in the GC t_o
- Heat pump design



$$\text{COP} = \frac{\Delta h_{2-3}}{\Delta h_{1-2}}$$

Integrated CO₂ Heat Pumps

Example of classification

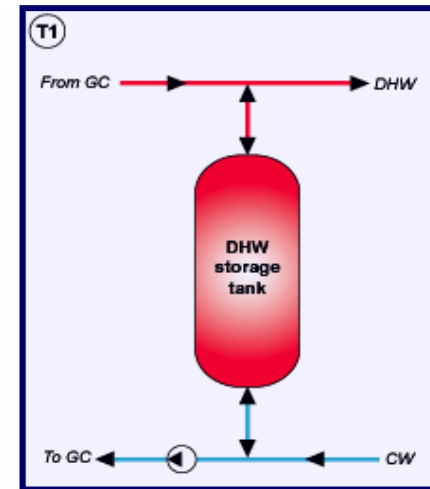
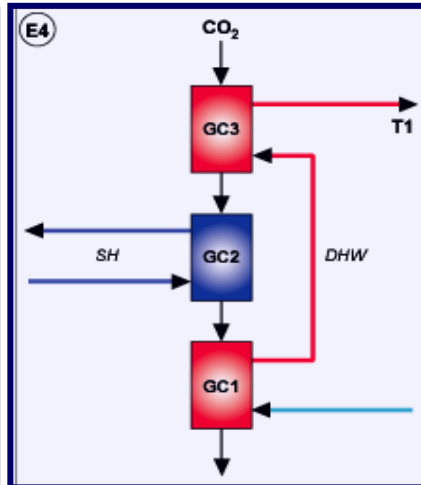
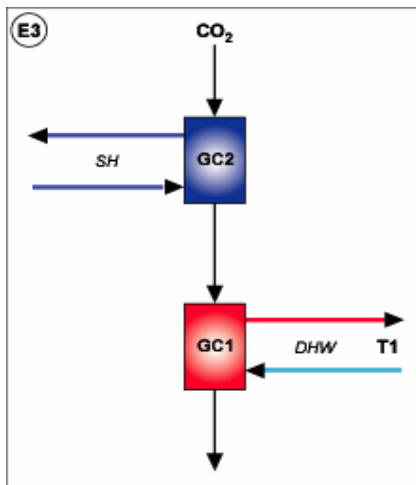
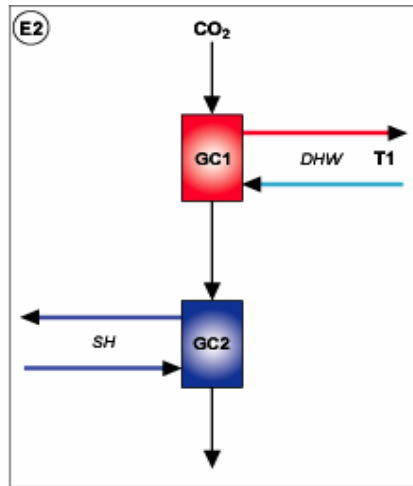
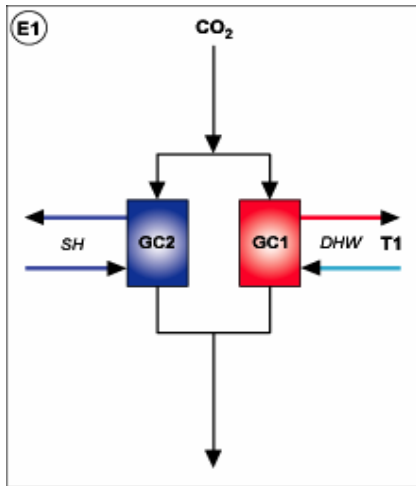


- 1) External gas cooler + single-shell DHW storage tank
 - Two gas cooler units (bipartite design)
 - Three gas cooler units (tripartite design)
- 2) External gas cooler + single-shell DHW storage tank with HX
 - Single gas cooler unit
- 3) Integrated CO₂ gas cooler and DHW storage tank
 - Gas cooler inside the tank
 - Gas cooler at the tank surface
 - Gas cooler in thermosyphon unit

Design of Integrated CO₂ Heat Pumps

1

External Gas Cooler + Single-Shell DHW Tank

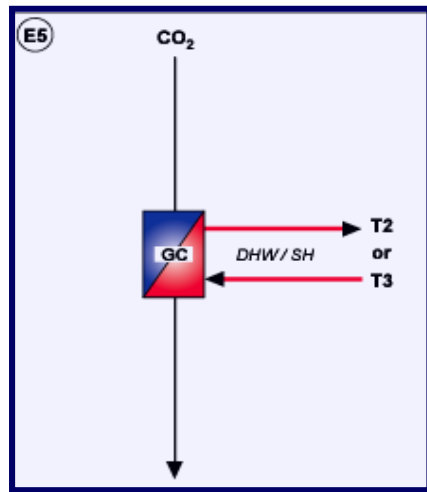


GC CO₂ gas cooler
SH space heating
DHW domestic hot water
CW city water

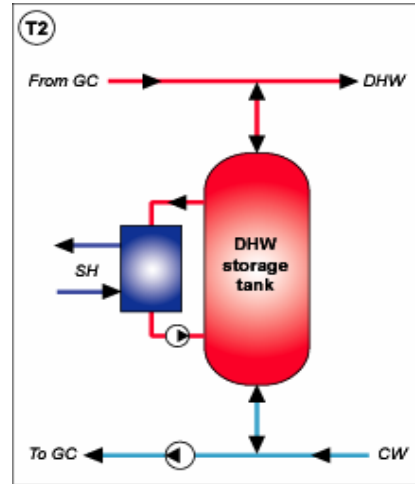
Design of Integrated CO₂ Heat Pumps

2

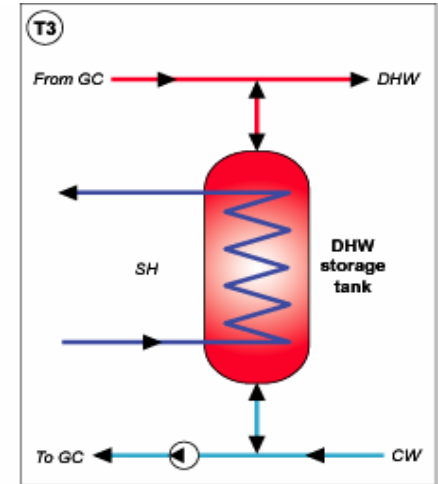
External Gas Cooler + Single-Shell DHW Tank with HXs



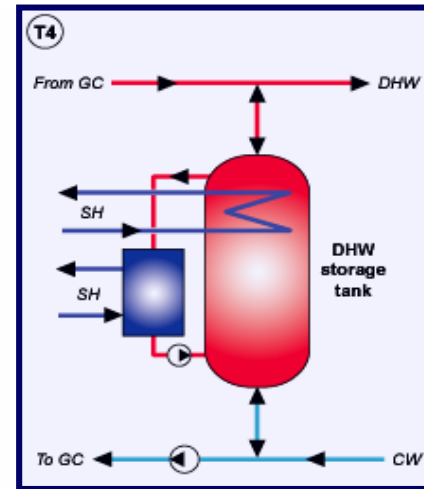
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or



or

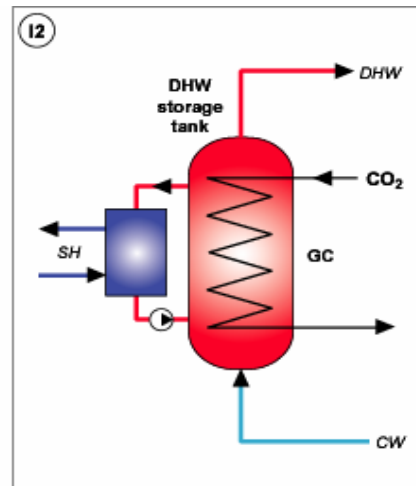
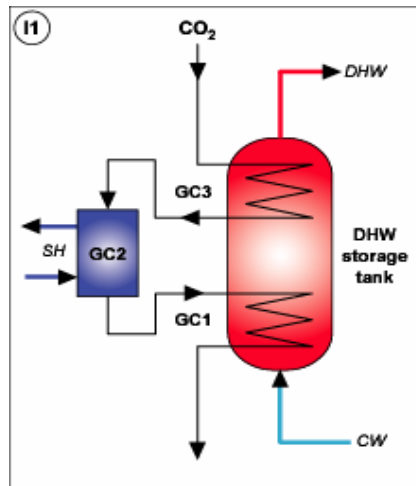


- GC** CO₂ gas cooler
- SH** space heating
- DHW** domestic hot water
- CW** city water

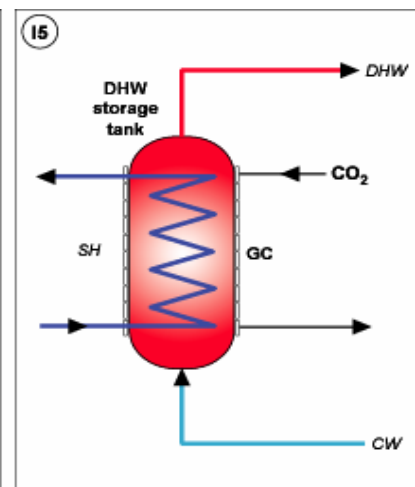
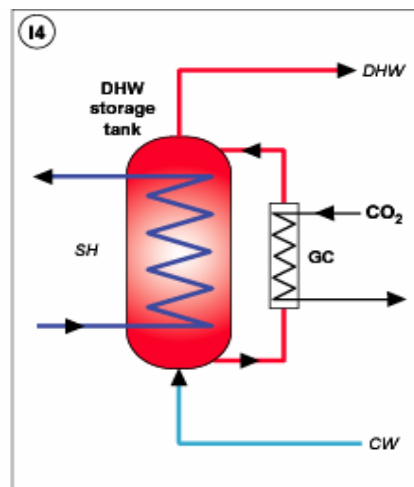
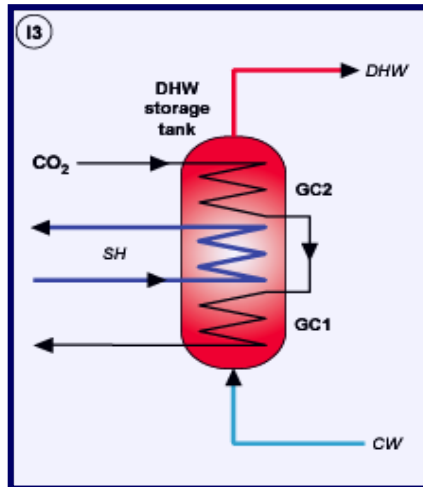
Design of Integrated CO₂ Heat Pumps

3

Integral Design for Gas Cooler and Single-Shell DHW Tank



GC CO₂ gas cooler
SH space heating
DHW domestic hot water
CW city water



Testing of Integrated CO₂ Heat Pumps

■ Operating modes

- Space heating only (SH mode)
- DHW heating only (DHW mode)
- Simultaneous space heating and DHW heating (Combined mode)

■ Apply existing standards – as far as possible

- EN 14511:2004 (space heating mode)
- EN 255-3:1997 (DHW heating mode)
- EN 14511 + EN 255-3 (Combined heating mode) ?

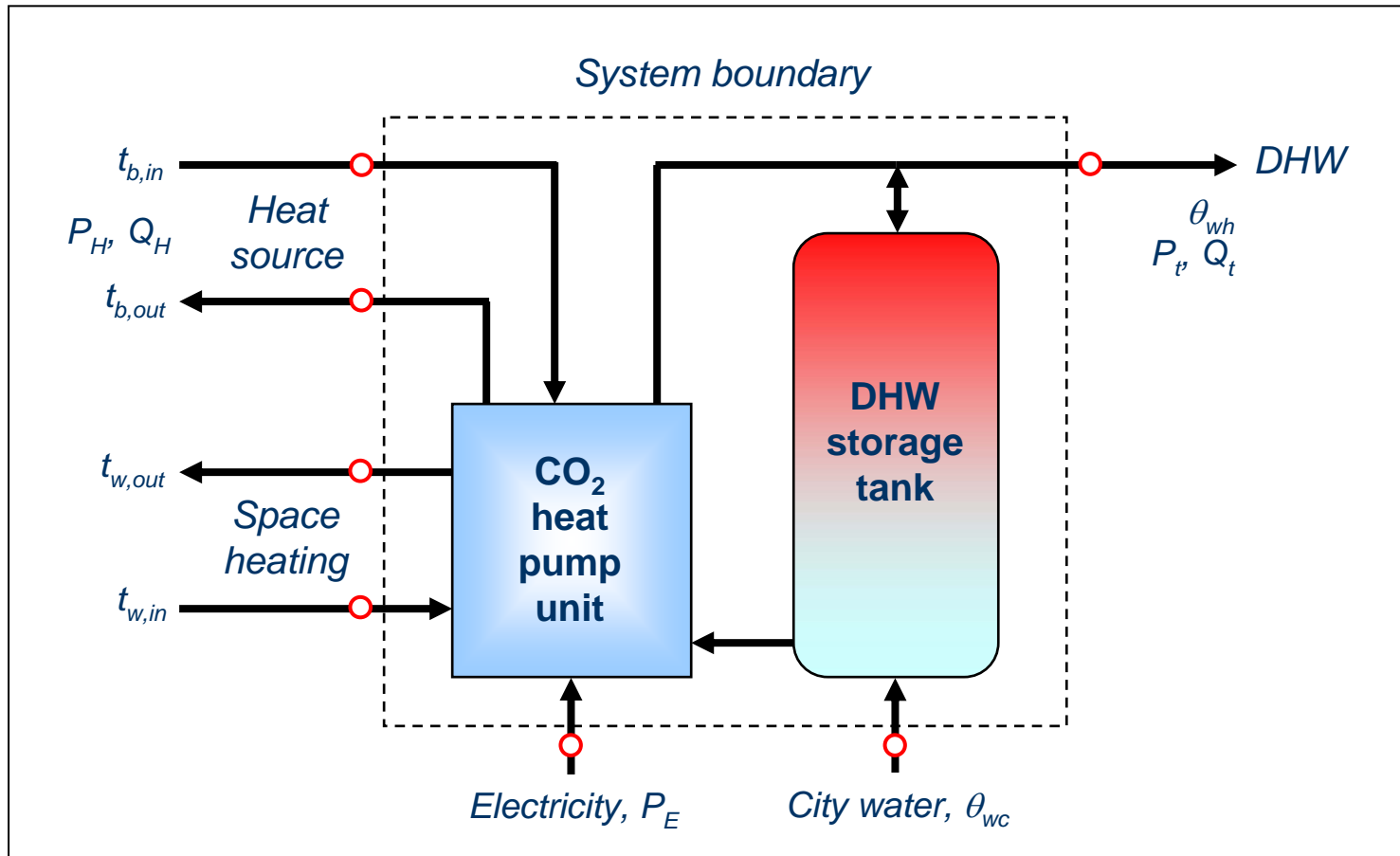
■ Important boundary conditions

- Supply/return temperature for space heating system
- City water temperature
- DHW storage temperature
- Testing of heat pump unit and DHW tank



Testing of Integrated CO₂ Heat Pumps

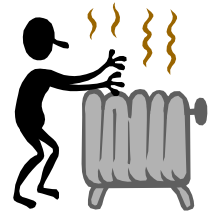
Example of Boundary Conditions and Variables



Important Conditions During Testing

1. Space Heating Mode *(revise EN 14511)*

- Reduced temperature level for systems with tripartite gas cooler
- Include power input for pumps for internal circulation of water
- Look at duration of stabilization period and test period



2. Hot Water Heating Mode *(revise EN 255-3)*

- Inlet city water temperature at 10°C
- Minimum 60°C hot water temp. for systems with external gas cooler
- Mixing valves should not be used (by-passed)
- Supplementary heating should be switched off
- Draw-off patterns – draw-off flow rates



3. Combined (Simultaneous) Heating Mode

- Combination of 1 and 2 – develop new test procedure

SINTEF Report 2005 – Integrated CO₂ HPs

- State-of-the-art technology
- Possible design of CO₂ systems
 - External gas cooler units – DHW tank
 - External gas cooler – DHW tank + HX
 - Integral design – GC and DHW tank
- Examples of integrated CO₂ HPs
- Recommended test conditions
 - Space heating mode
 - DHW heating mode
 - Combined heating mode
- Method for calculating SPF

