





Shift your perspective

Danfoss solutions for 150g R290 W/W heat pumps



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Context

Phase down

Product bans



Figure 1 - Placing on the EU Market of virgin HFCs Source: European Commission

Stationary air-conditioning and heat-pumps			Safety Exemption applicability	Stationary air-conditioning and heat-pumps			Safety Exemption applicability
8. Self-contained air- conditioning and heat pump equipment, except chillers, that:	Plug-in room air-conditioning equipment which is movable between rooms by the end user that contain HFCs with GWP of 150 or more;	1 January 2020		9. Split air- conditioning and heat pump	Single split systems, containing less than 3 kg of fluorinated 1 January greenhouse gases listed in Annex I, that contain, or whose functioning relies upon, fluorinated greenhouse gases listed in Annex I with OUR of ETG services.		
	Plug-in room air-conditioning equipment, monobloc air-conditioning equipment, other self-contained air- conditioning equipment and self-contained heat pumps, with a maximum rated capacity of up to and including 12 kW that contain fluorinated greenhouse gases with a GWP of 150 or more, except If required to meet safely requirements at the site of operation. If safety requirements at the site of operation. If safety requirements a the site of operation would not allow using fluorinated greenhouse gases with GWP of less than 150, the GWP limit is 750;	1 January 2027	 ✓ 	equipment.	Spit air-to-water systems of a rated capacity up to and including 12 kW containing, or whose functioning relies upon, fluorinated greenhouse gases with a GWP of 150 or more, except when required to meet safety requirements at the site of operation;	1 January 2027	*
					Split air-to-air systems of a rated capacity up to and including 12 kW 1. containing, or whose functioning relies upon, fluorinated greenhouse gases with a GWP of 150 or more, except when required to meet softw remument at the site of oneration:	1 January 2029	¥
	Plug-in room, monobloc air-conditioning and other self-contained heat pump equipment, with a maximum rated capacity of up io including 12 WV that contain fluorinated greenhouse gases, except when required to meet safety requirements at the site of operation. When safety requirements at the site of includion availand a talken usion alternatives	1 January 2032 Subject to review before 2030	*		Split systems of a rated capacity up to and including 12 kW, containing, or whose functioning relies upon, fluorinated greenhouse gases, except when required to meet safety requirements at the site of operation;	1 January 2035 Subject to review before 2030	~
	to fluorinated greenhouse gases, the GWP limit is 750; Monoblock and other self-contained air-conditioning and heat pump equipment, with a maximum rated capacity of larger than 12kW but not exceeding 50 kW that contain fluorinated greenhouse gases with a GWP of 150 or more, except when required to meet safely requirements, at the site of operation. When safety requirements at the site of installation would not allow using alternatives to fluorinated greenhouse gases with GWP of 150 or less, the GMP limit is 750;	1 January 2027	~		Split systems of a rated capacity of more than 12 kW containing, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more, except when required to meet	1 January 2029	~
					satety requirements at the site of operation; Split systems of a rated capacity of more than 12 kW containing, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except when required to meet safety requirements at the site of operation.	1 January 2033 Subject to review before 2030	~
	Other self-contained air-conditioning and heat pump equipment that contain fluorinated greenhouse gases with GWP of 150 or more, except when required to meet safety requirements, at the site of operation. When safety requirements would not allow using fluorinated greenhouse gases with GWP of 150 or less, the GWP limit is 750.	1 January 2030	~	Table 4 (Part 2)- Pump equipme	Annex IV product bans for stationary Air C nt	onditioning	and Heat

Source: EPEE F-gas brochure



Our vision about R290 in HP Applications According to IEC 60335-2-40 ed7



R1234ze <10GWP R516A/R454C/R455A <150GWP R32/R454B <750GWP

	Type of System	Can leak indoor -> leak detector $f(room m^2)$	R290 likelihood	Comments	
	A/A Residential Split	Y / Y	•	 Enhanced tightness in New Build Circulation Airflow/Releasable Charge in Renovation A2L alternative: R454C/R455A or R32 	
	A/W Residential Split	Y / N	•	 Most likely replaced by Monoblock (at least in New build) Releasable Charge only effective option A2L alternative: R454C/R455A or R32 	
	 A/W Monoblock Residential Light Comm. Commercial 	N / na	•	 No concern >1 circuit above 70-75kW Modular architecture on the water side or EN378 revision A2L alternative: R516A/R454C/R455A or R32/R454B 	
	Exhaust A/W	Y / N	•	 Unit design is made for Ventilated Enclosure 	
	 B-W/W Monoblock Residential Light Comm. Commercial 	Y / N	•	 Charge >10kW is an issue despite Releasable Charge Alternative: Ventilated Enclosure Alternative: Outdoor design A2L alternative: R454C/R455A or R32/R454B Machinery Room likely available in Commercial A2L alternative: R1234ze 	
Single family: GSHP — HIGH — MEDIUM — LOW Multi family: "apartment booster" in ambient loop or 5G DH					



Main challenges

The challenges when attempting to develop a very low charge heat pump are several, 3 major axis we worked on:

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Internal volume

Must be minimized especially on the liquid side:

- Short & small diameters piping
- Compact line components
- Relocation of filter drier to suction

Heat exchangers

Internal volume reduction:

- Press depth
- Heat transfer

Danfoss new MPHE are perfect for the job:

- H39-EZU as evaporator (and condenser for reversible systems)
- H30-CW as condenser for heating only systems

Compressor

- Minimum oil charge
- Oil type (PAG vs POE)
- Design type (low vs high side)
- Minimal free volume

Specific Danfoss VRN rotary meets most criterias

5 Chillventa 2024





R290 micro-plate heat exchangers lineup





The rotary compressor

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The compressor is the most important component, the heart of the system as usual, but also plays a critical role in the final system refrigerant charge.

Specifications of the ideal compressor:

- Low internal free volume
- Low side design
- PAG oil
- Low oil charge

This model meets most of those characteristics and is very likely one of the most if not the most suitable compressor available in the market.



B0°C/W35°C	g	%
Compressor	23.8	16%
Oil	24.1	16%
Condenser	51.0	34%
Evaporator	40.7	27%
Lines	12.1	8%
TOTAL	151.6	100%





R290/RA39X

SDT (°C)



Brand 📩	Danfoss	Danfoss	Alternative 1	Alternative 2
Design	Single rotary High side	Single rotary High side	Scroll Low side	Twin rotary High side
Swept volume	14	15	29	21
Oil type	PAG	POE	POE	PAG
Oil quantity	0.15	0.48	0.744	0.25



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Simulated design: 2.645L



Assembled & tested design: ~2.02L (-24%)

	tube diameter (inch)	length (m)
Discharge line, CP to 4WV	3/8	0.95
Discharge line, 4WV to CDS	3/8	0.05
Liquid line, CDS to EXV	1/4	0.045
Liquid line, EXV to EVP	1/4	0.045
Suction line, EVP to 4WV	1/2	0.05
Suction line, 4WV to CP	1/2	0.9

Component	Manfoss	
Compressor	VRN	
Inverter	CDS203	
Evaporator	H39-EZU	Let's talk for
Condenser	H39-EZU	the full bill of
EXV	ETS5M	materials
4WV	STF	
Controller	CX06	











Charge optimization (simulations) - B0/W35@120 rps





Charge optimization – B0/W35@60rps

2500

2000

1500

1000

500

0

70

90

The optimal charge is obtained at 130g R290 with a COP of 4.13

Charge optimization was run at 60rps instead of the maximum speed

This is conservative, at maximum speed the system will be slightly overcharged and COP slightly impacted

158g simulated vs 130g tested

Tested internal volume is lower

Trends still match very well.

Dymola model +/- 30% uncertainty in 2

phase (evaporator and condenser)

Source of discrepancy:



HeatingCap_Ph[W]

110

130

Charge (grams)







(3)



Performance points - Heating



E condition B0/W35: • COP=4.13 SC=7K @60rps

COP=3.85 SC=9K @120rps

Note: pump correction not included

Delta:

- Charge optimization @60rps
- Lower approach @60rps
- High motor efficiency @60rps
- Lower drive efficiency @60rps

	СОР		Heating Capacity		
	LT MT		LT	МТ	
E point biv -7	3.85	2.64	4.71	4.12	
A point biv -7	3.92	2.78	4.71	4.2	
C point biv -7	5.26	4.08	1.86	1.66	
Aerotherm -10Brine	2.98	2.15	3.42	2.99	









Performance points – Cooling

Co-current operation





Conclusions



We are able to meet/exceed the requirements:

- 130g R290 optimized charge @60rps
- B0W35: 4.71kW with a COP of 3.85 @120rps or 2.26kW with a COP of 4.13 @60rps
- B-10W35: 3.82kW with a COP of 2.98



Potential for further optimizations:

- The charge optimization has to be made based on the speed that will be used with the final product
- There is a 20g+ R290 margin that can be used for the addition of the filter drier but also to increase the number of plates of the MPHEs
- The compressor and piping have to be insulated to reduce heat losses that are significant with high side compressors



Benchmark:

- Exceeds in performance and in charge the only such unit certified on the market (HP Keymark)
- Exceeds in performance and/or in charge other available reference from the valuable projects already completed at Fraunhofer or Cetiat institutes (that were using some of Danfoss products but not the latest ones)







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Thank you for your attention! Let's meet at the Danfoss Booth Hall 7, booth 251





