



BEYOND
THE BROCHURE

EXPOSING THE REALITY OF REFRIGERATION PRODUCT UNDERPERFORMANCE

In an industry moving rapidly toward low Global Warming Potential (GWP) refrigerants, reliable performance data is vital.

Yet new laboratory testing of selected heat rejection products has uncovered significant inconsistencies in non-certified manufacturer data and measured performance. This white paper examines the risks these discrepancies pose and how independent certification can ensure transparency and trust.

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DISCLAIMER

This white paper has been produced by Eurovent Certita Certification for informational and educational purposes only.

The analyses, results and conclusions presented herein are based on a defined scope of work, a limited sample of products, specific assumptions, and test conditions as described in the document. The findings reflect the outcomes of this study only and do not constitute a general assessment of the market, nor of any individual manufacturer, brand, or product. All testing, simulations and evaluations were conducted using recognised standards, independent laboratories and professional tools, in accordance with the methodologies described.

References to market practices, performance deviations, or environmental claims are made at a general level and are not intended to imply misconduct, non-compliance, or misrepresentation by any specific company.

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EXECUTIVE SUMMARY

PREFACE

The HVAC and refrigeration (HVACR) industry is facing a perfect storm of challenges, from tightening environmental regulations and rising energy costs to growing concerns over greenwashing and unreliable product data. As pressure mounts to reduce carbon emissions, adopt low-GWP refrigerants, and traverse an unpredictable energy market, manufacturers and specifiers alike must navigate a complex landscape of innovation, compliance, and performance assurance.

At the same time, a lack of independently verified HVACR product data continues to undermine progress, with decision makers unknowingly specifying products that underperform. Against this background, this white paper demonstrates why the need for product performance certification and data transparency is more important than ever.

OBJECTIVES

The objectives of the white paper are twofold:

1) Identify deviations between declared and measured performance for a defined and limited sample of non-certified heat rejection products

Eurovent Certita Certification experts have compared data claimed by manufacturers with measured data in a comprehensive (state-of-the-art) evaluation process including laboratory tests, data analysis and evaluation via a professional design tool. The evaluation includes heat rejection, fan power and acoustics.

2) Demonstrate the benefit of third-party certification

Each Eurovent Certita Certification programme has its own Technical Certification Rules (TCR), which sets out the rules of that specific certification scheme. Eurovent Certita Certification works in collaboration with certified manufacturers and industry stakeholders to create TCRs so that the data verified aligns with market needs. As a part of the Eurovent Certified Performance programme for Heat Exchangers, 'correction factors' have been developed that help to transition the performance data collected under standard conditions to a range of market conditions that mimic (real) operational conditions across different climates. This white paper provides detailed analysis to show how relevant Eurovent Certita Certification's TCRs are, by comparing measured data from laboratory tests with that calculated/expected via correction factors across different market conditions.

REFRIGERANT PERFORMANCE AND UTILISATION

Modern refrigeration systems rely on various refrigerants, primarily HFCs (Hydrofluorocarbons), HFOs (Hydrofluoroolefins), and CO₂ (Carbon Dioxide). Each of these refrigerants demonstrates strong performance in cooling applications, but their characteristics and environmental impacts differ significantly.

PERFORMANCE OVERVIEW

HFC/HFO refrigerants:

- Offer high energy efficiency and are almost compatible with existing refrigeration technologies with slight modifications to take into account its low flammability.
- HFOs, in particular, are designed to have very low Global Warming Potential (GWP) compared to traditional HFCs, making them more sustainable.
- Suitable for a wide range of applications, including commercial refrigeration, air conditioning, and heat pumps.

CO₂ (R-744):

- A natural refrigerant with zero ozone depletion potential and an extremely low GWP (=1).
- Performs well in transcritical systems, especially in colder climates, and is increasingly used in supermarkets and industrial refrigeration.
- Requires higher operating pressures and specialised system design.

KEY DIFFERENCES IN UTILISATION

HFC/HFO systems:

- Easier retrofit options for existing systems.
- Lower initial investment compared to CO₂ systems.
- HFO blends are often used to meet stringent environmental regulations without sacrificing performance.

CO₂ systems:

- Ideal for end users prioritising sustainability and regulatory compliance.
- Higher complexity and cost due to pressure requirements and system design.
- Best suited for large-scale commercial and industrial applications.

Importance of low-GWP refrigerants

- Global regulations (e.g., EU F-Gas Regulation) are driving the phase-down of high-GWP HFCs.
- Using HFOs and low-GWP HFC blends significantly reduces environmental impact while maintaining efficiency.
- CO₂ adoption aligns with long-term sustainability goals and future-proofing against regulatory changes.

GROWTH OF CO₂ SYSTEMS

CO₂ (R-744) refrigeration systems are gaining strong momentum in both commercial and industrial cooling applications. Supermarkets, cold storage facilities, food processing plants, and logistics hubs are increasingly adopting transcritical systems due to their energy efficiency, sustainability, and compliance with F-Gas regulations. As demand grows for climate-friendly, effective, reliable, refrigeration solutions, CO₂ has emerged as a viable, future-proof alternative to traditional HFC-based systems.

A rise in popularity comes hand in hand with a rise in available systems. For decision makers this means more choice, but it also means that product data needs to be comparable to enable informed product selection and accurate to enable good system design. However, not all refrigeration products have independently verified performance data across a range of operating conditions. Also, the product data available from different manufacturers may vary, making direct comparison difficult. Without verified and comparable data, a gap may appear between the performance claimed by the manufacturer and the performance experienced by the end user under certain operating conditions.

Accurate data is critical to the effective specification, design, installation and operation of all heating, ventilation, air conditioning and refrigeration (HVACR) systems – regardless of the refrigerant or system type. Closing the performance gap not only protects HVACR professionals and end users from underperforming systems but also protects quality manufacturers and the credibility of natural refrigerants.

THE IMPORTANCE OF THIRD-PARTY VERIFICATION

Past study on HFC condensers

Few years ago, Eurovent Certita Certification conducted a project analysing the performance of HFC air-cooled condensers. The study found deviations between the measured and claimed performance for the products analysed within the scope of the study across a range of performance criteria. Table 1 illustrates a summary of the results.

Table 1: Deviation between the measured and claimed performance

Performance	Air-cooled HFC condenser 1	Air-cooled HFC condenser 2	Air-cooled HFC condenser 3
Heat rejection capacity	-17,42%	-32,54%	-8,04%
Air flow	-4,62%	-20,38%	1,57%
Power input	-21,05%	-25,68%	-15,38%

The sign “-” means underperformance

Past data analysis on CO₂ gas coolers

In 2024, Eurovent Certita Certification conducted a data analysis on 48 uncertified CO₂ gas coolers. Models were chosen by Eurovent Certita Certification and selected from units with publicly accessible technical data sheets. The study compared claimed and expected heat rejection under several market operating conditions installable in central and northern European climates.

The aim was to ascertain whether there were deviations between the unverified data declared by the manufacturer and the expected performance of the unit.

The study revealed:

- Discrepancies between uncertified claimed and expected performance in all gas coolers evaluated within the study.
- The worst underperforming unit had a 31% gap between its claimed and expected performance.
- The average deviation across all units was 23%
- The lowest deviation was 12%.

The findings were published as part of the white paper [Broken Trust: Energy efficiency and the refrigeration industry](#)¹.

The results showed that without independent third-party verification, there may be a higher risk that the claimed data may overstate the heat rejection capacity, leading to systems that underperform.

In this this white paper, Eurovent Certita Certification has extended the study by performing real tests on units. These units have been tested under several market conditions including standard conditions, the market conditions used for the previous study above and the market condition for warm climates.

¹ [Download the white paper](#)
[Broken Trust:](#)

INDUSTRY CHALLENGES

CONSEQUENCES OF INACCURATE PERFORMANCE DATA

The best designed and installed systems may underperform if the performance of components within the system does not match manufacturer claims. For installers, specifiers, and end users, if manufacturer claims are inaccurate, it makes it difficult to make informed choices, ultimately putting projects, budgets, and sustainability goals at risk.

The consequences of underperforming products include:

- Non-compliance with regulations
- Increased energy consumption and higher running costs
- Larger carbon footprint and missed sustainability goals
- Systems that are unable to meet the needs of the client
- Excess noise
- Faults and breakdown - products must work harder to meet the required heat rejection
- Negative impact on the performance and energy consumption of other parts of the system
- Complaints, penalties and potential litigation
- Reputational damage - not just to HVAC businesses, but to refrigeration products and the industry at large.

Without independent testing it can be hard to verify product performance claims.

All industry players are let down by inaccurate product data. It creates an unfair market for manufacturers and creates risk for decision makers, designers, installers and end users.

GREENWASHING

Greenwashing practices as identified in regulatory guidance and industry standards pose a significant threat to genuine sustainability progress in the refrigeration industry. As environmental responsibility becomes a stronger selling point, companies can overstate, exaggerate, or misrepresent the environmental benefits of products. Additionally, greenwashing schemes in the form of unverified or self-awarded "eco" labels and logos have entered the market, undermining the value of genuine sustainability programmes.

These practices not only mislead buyers and erode trust but also create an uneven playing field where truly efficient, sustainable technologies may struggle to stand out.

Other greenwashing tactics include:

- Using “up to” performance figures taken from ideal lab conditions, or highlighting a best-case test point,
- Overemphasising one green feature, e.g. promoting a low-GWP refrigerant while ignoring poor energy performance,
- Comparing a new product to an outdated or deliberately inefficient benchmark to make the gain look bigger,
- Using vague terms like “eco-friendly,” “planet-positive,” or “green-certified” without reference to measurable, verified criteria.

Independent certification and transparent testing are important tools in combating greenwashing and ensuring accountability across the supply chain.

How to spot a greenwashing scheme:

- Entry criteria that is not transparent e.g. technical information on the award process, or what constitutes a pass or fail is not publicly published or available.
- No requirement for controls such as laboratory tests or audits by independent third parties.
- Self-declaration, meaning that the information provided is not independently verified.
- Without robust entry criteria, participants of such schemes are simply buying an “eco-friendly” logo.

CHOOSING THE RIGHT CERTIFICATION SCHEME

The aim of any kind of product certification scheme is to build trust within the industry and provide reliable data to the market. While criteria and processes may vary between certifiers and schemes, the certification process generally includes independent testing activities performed by third-party laboratories.

Generally, laboratories are accredited and test equipment according to specific International or regional standards, which define test methodologies and conditions. This ensures that tests are reproducible – same results for the same equipment tested – and fair, as tests will be performed in the same manner for equipment A and B.

However, those standard test conditions can vary between schemes and do not always match specific customer requirements or climatic zones; this means designers can be missing key information when designing the whole system or installation.

The case study on the following pages shows the importance of verifying data across different climates (market conditions) and the value of third-party validation through a standardised, rigorous and comprehensive product certification process.

NEW TEST CAMPAIGN: ON CO₂ GAS COOLERS

AIMS AND METHODOLOGY

Eurovent Certita Certification put uncertified CO₂ gas coolers through a comprehensive evaluation process including independent laboratory tests, data analysis and evaluation via a professional design tool. The units were randomly selected from uncertified units on the market. The aim was to ascertain:

- If there were any discrepancies between the manufacturers claimed data and the expected and measured performance for the units evaluated.
- What impact those discrepancies would have on the whole refrigeration system in terms of energy consumption, running costs and carbon footprint over the lifetime of the product.

The units went through an identical evaluation process. The data sheet and design tool analysis were undertaken by Eurovent Certita Certification. Performance tests were undertaken by an independent laboratory to the Eurovent Certified Performance for Heat Exchangers testing protocol.

COLLECTION OF OFFERS

It was critical for the research to follow an authentic customer journey to replicate a real-world experience, and to provide a snapshot of products available on the market.

Eurovent Certita Certification therefore created a project specification and approached independent distributors for an offer. Eurovent Certification received five (5) offers from the distributors.

The offers included heat rejection capacity of the units under standard and different market conditions as follows:

- **Condition 1:** Standard transcritical condition (known as SC20)
- **Condition 2:** Market transcritical condition at High ambient T with 2K approach used in warm weather areas
- **Condition 3:** Market transcritical condition with 3K approach used in Central and Northern European market (In the Eurovent Certified Performance for Heat Exchangers TCR this is known as C3)
- **Condition 4:** Market transcritical condition with 2K approach used in Central and Northern European market (In the Eurovent Certified Performance for Heat Exchangers TCR this is known as C2)
- **Condition 5:** Standard subcritical condition (Condenser) known as SC25.

Table 2: Operating conditions in transcritical mode

Condition in transcritical mode	Gas Cooler inlet pressure	Gas Cooler inlet temperature	Air Inlet temperature	Gas Cooler outlet temperature	DT (temperature approach)
Condition 1 (standard condition SC20)	90 bar	110 °C	30 °C	35 °C	5 K
Condition 2	92 bar	110 °C	35 °C	37 °C	2 K
Condition 3	80 bar	100 °C	29 °C	32 °C	3 K
Condition 4	80 bar	100 °C	30 °C	32 °C	2 K

Table 3: Operating conditions in subcritical mode (operating as a Condenser)

Condition in subcritical mode	Air inlet temperature	Condensing temperature	Refrigerant inlet temperature	Subcooling
Standard condition SC25	5 °C	15 °C	60 °C	<3 K

PERFORMANCE SIMULATIONS WITH A PROFESSIONAL DESIGN TOOL

The technical data from these offers were entered into a professional design tool to simulate the performance. Items needed for the design included:

- Tubes circuiting
- Fin spacing
- Surface area of exchange
- Tube and fin materials
- Air flow rate
- CO₂ mass flow rate in tubes
- Operating conditions.

The design tool calculated the predicted heat rejection capacity of the units under standard and different market conditions.

The results from the design software simulations revealed that while units behaved reliably at Standard Condition 20, the average underperformance at condition 4 was 32% and the average underperformance at condition 3 was 26% as shown in table 4.

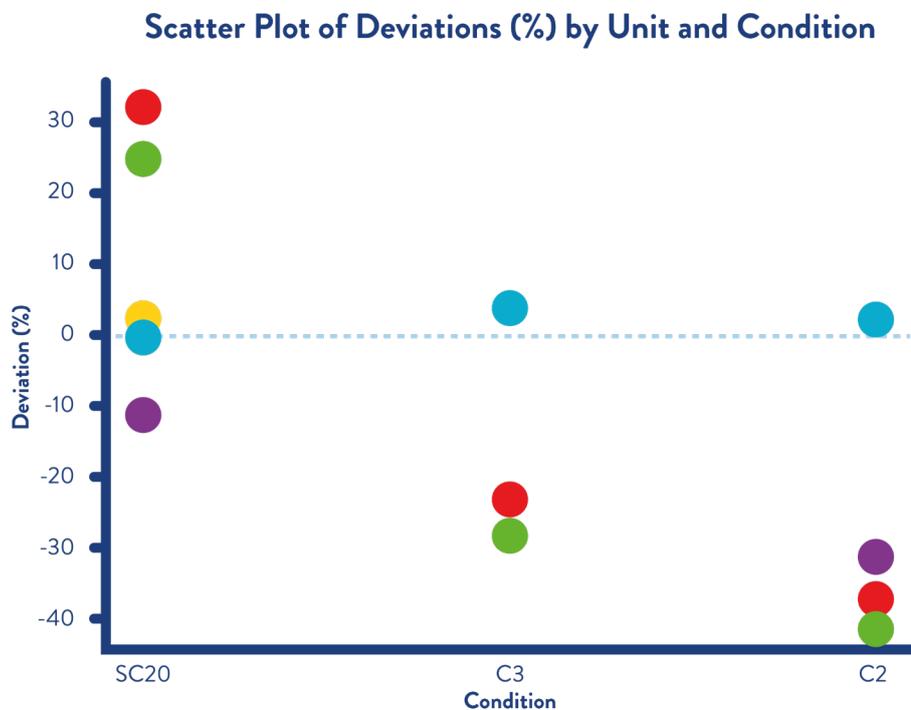
Table 4: Design tool calculation results: deviation on performance

Operating condition	Unit A	Unit B	Unit C	Unit D	Unit E
Condition 1 (standard condition SC20)	0%	2%	21%	32%	-11%
Condition 2	2%		-21%	-16%	-17%
Condition 3	3%		-28%	-23%	-27%
Condition 4	2%		-41%	-37%	-31%

The sign “-“ means underperformance

The figures correspond to the findings of the data analysis in the original white paper, Broken Trust, which found an average deviation of 23% across all C conditions (conditions 3 and 4) with the worst performing unit reaching a 31% gap between its claimed and expected performance.

Figure 1: Deviations by unit and condition according to the performance simulation with a professional design tool



The graph offers a snapshot of non-certified units available on the market. The data gained through the design tool simulations showed that only one (1) of the five (5) units from the offers had claimed data that aligned with expected performance across the market conditions: C3 (Condition 3 in table 4) and C2 (Condition 4 in table 4).

While the compliant unit demonstrates that not all non-certified units hold inaccurate product data, it shows the importance of choosing a product with third-party verified performance.

PRODUCT SELECTION AND PURCHASE

The results from the design software simulations showed two (2) units from the five (5) non-certified models displayed a significant performance gap within the scope of the simulation assumptions. These units were selected and put forward for the laboratory testing campaign.

The two units were purchased from the distributor by Eurovent Certita Certification. To ensure impartiality and fair testing, Eurovent Certita Certification had no direct contact with the tested units. An independent Legal Officer (French Bailiff) inspected the units on arrival at the distributor's warehouse and undertook a second inspection when the units arrived at the laboratory. This ensured that the units tested were the same as those put forward in the offer. The Legal Officer was also present at the unpacking (to make sure both units arrived undamaged), and during the installation of the units on the test rig.

TESTS BY AN INDEPENDENT LABORATORY

The two gas coolers undertook an identical evaluation/test protocol as the one used for Eurovent Certified Performance by using the test standard EN327 to measure:

- Heat rejection Capacity: testing under both subcritical / transcritical conditions
- Fan power consumption
- Air flow rate
- For the sound measurement, the test standard EN 13487:2019-11 and EN ISO 9614-1:2009-11 was used for determination of sound power levels.

For the heat rejection capacity, each unit was evaluated under five (5) different operating conditions illustrated in the table 2 and 3 of this document.

TEST RESULTS

HEAT REJECTION CAPACITY

The laboratory test results were compared to the heat rejection capacity claimed by the manufacturer.

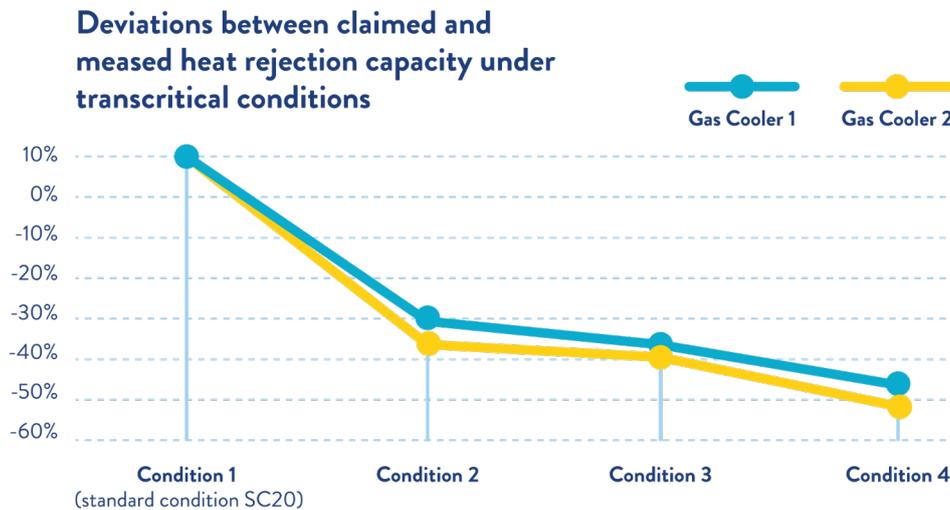
Both units were found to have significant deviations between claimed and measured heat rejection capacity under the tested operating conditions.

Table 5: Deviations between claimed and measured heat rejection capacity

Operating Conditions	Gas Cooler 1	Gas Cooler 2
Condition 1 (standard condition SC20)	8%	8%
Condition 2	-33%	-37%
Condition 3	-39%	-41%
Condition 4	-50%	-53%
Condition 5 (SC25: condenser)	-32%	-23%

The sign “-” means underperformance

Figure 2: Evolution of deviation between the claimed and measured heat rejection capacity of gas coolers under transcritical conditions



The highest deviation is found when the units are operating under condition 4 (i.e., the C2 condition in Eurovent Certita Certification’s heat exchangers technical certification rules) with more than 50% deviation for both units. The condition 3 (i.e., the C3 condition in Eurovent Certita Certification’s heat exchangers technical certification rules) is the second condition under which the units significantly underperform. This confirms the initial technical hypothesis established for the purpose of this study.

ACOUSTIC PERFORMANCE

The laboratory test results were compared to the sound power level claimed by the manufacturer. One unit was found to have significant deviation between claimed and measured performance of 5dB(A) under the standard test conditions.

Table 6: Deviations between claimed and measured sound power level (dB(A))

Conditions	Gas Cooler 1	Gas Cooler 2
Standard condition	1 dB(A)	5 dB(A)

FAN POWER CONSUMPTION

The laboratory test results were compared to the fan power consumption claimed by the manufacturer. Both units were found to have low deviations between claimed and measured performance under standard test conditions.

Table 7: Deviations between claimed and measured fan power

Conditions	Gas Cooler 1	Gas Cooler 2
Standard condition	-6%	2%

IMPACT OF UNRELIABLE DATA ON A REFRIGERATION SYSTEM

CALCULATING WHOLE SYSTEM UNDERPERFORMANCE

Heat rejection equipment such as HFC condensers and CO₂ gas coolers do not work in isolation, they are important components within a refrigeration system. To evaluate the true impact of product underperformance, Eurovent Certita Certification therefore decided not to compare the intrinsic consumption of the component, but to compare the overall performance of a complete system based on defined simulation assumptions (cooling pack consumption).

Using simulation software, the impact of underperforming heat rejection devices was calculated using two typical technical solutions for a supermarket application for illustrative purposes:

- System 1: CO₂ transcritical installation
- System 2: Medium temperature (MT) and low temperature (LT) HFC installation.

Both systems were put through a range of simulations to calculate the impact of underperformance based on the following set-up:

System size:

- Medium temperature (MT): T_{eva} = -8 °C; Q_{eva} = 180 kW
 - ◊ 112 kW from cabinets – 62%
 - ◊ 68 kW from coldrooms – 38%
- Low temperature (LT): T_{eva} = -30 °C; Q_{eva} = 50 kW
 - ◊ 23 kW from cabinets – 46%
 - ◊ 27 kW from coldrooms – 54%

Baseline: +2K approach point temperature difference (condenser / gas cooler outlet – ambient)

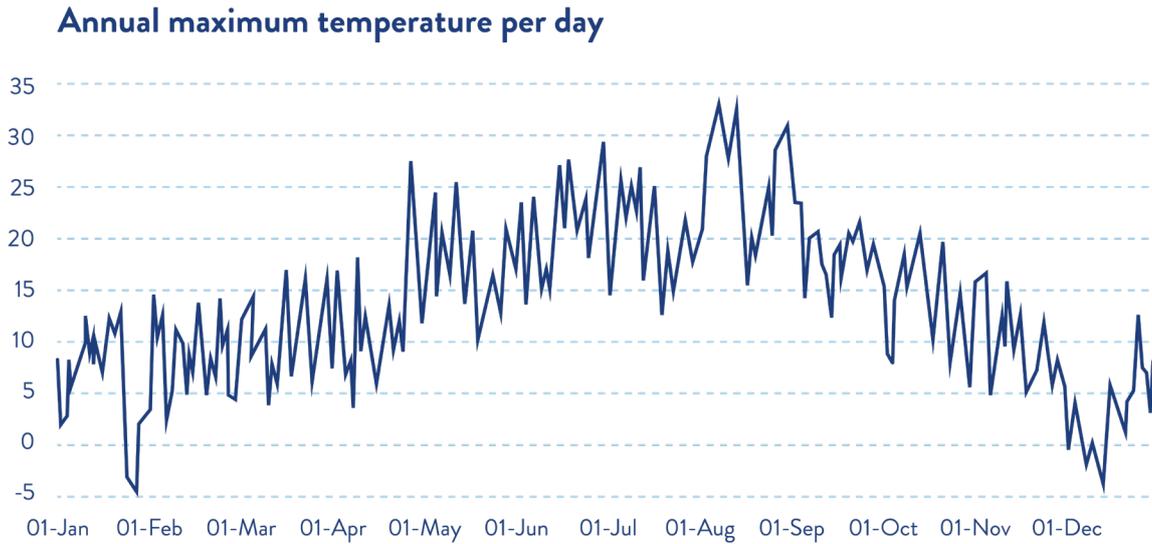
Climate profile [1]: München (DE)

Pack typology: CO₂ booster and R448a

Emission factor [2]: 338 gCO₂/kWh – average from 2020–2023

Electricity cost: 0,18 €/kWh

Figure 3: Annual maximum temperature per day



Sources:

[1] https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#TMY

[2] <https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1-1751032678/greenhouse-gas-emission-intensity-of-electricity-generation-country-level?activeTab=570bee2d-1316-48cf-adde4b640f92119b>

CASE STUDY SYSTEM 1: CO₂ TRANSCRITICAL INSTALLATION

Heat rejection is performed by a CO₂ gas cooler which operates under different conditions with underperformance for each condition listed in the table 8.

The average underperformance from both tested gas coolers is used to calculate the underperformance, which is expressed as increased delta T for the simulations. This translates the lost capacity into a reduced temperature change across the gas cooler. This results in a significantly higher outlet temperature, which may lead to increased high-side pressure and compressor energy consumption, and may reduce overall system capacity and efficiency.

Table 8: Underperformance according to each condition based on test results

Operating Conditions	Av. deviation	Increased delta T
Condition 3 (C3 in TCR)	-40%	+ 2 K (CO ₂ outlet Temperature 34°C instead of 32°C)
Condition 4 (C2 in TCR)	-51,5%	+ 2.6 K (CO ₂ outlet Temperature 34.6°C instead of 32°C)
Condition 5 : Condenser (CO ₂ Subcritical operation)	-32%	+ 3.5 K (CO ₂ condensing Temperature 18.5 °C instead of 15°C)

The gas cooler operates as a condenser for T ambient ≤18°C and in transcritical mode when T ambient >18°C.

Table 9: Underperformance of a CO₂ installation at alternatively Condition 3 and Condition 5

Condition 3 (C3 in TCR)	1 year	10 years	15 years
Percentage difference vs. baseline [%]	+ 11,5%	+ 11,5%	+ 11,5%
Additional energy [kWh]	43586	435864	653795
Additional cost [€]	7846	78455	117683
Additional CO ₂ emission [tons]	14,7	147,3	221

Table 10: Underperformance of a CO₂ installation at alternatively Condition 4 and Condition 5

Condition 4 (C2 in TCR)	1 year	10 years	15 years
Percentage difference vs. baseline [%]	+ 11,6%	+ 11,6%	+ 11,6%
Additional energy [kWh]	43935	439354	659031
Additional cost [€]	7908	79084	118625
Additional CO ₂ emission [tons]	14,9	148,5	222,8

CASE STUDY SYSTEM 2: HFC INSTALLATION

Heat rejection is performed by a HFC condenser using R448a refrigerant with a 32% underperformance. The 32% underperformance is based on the previous study on HFC condensers (table 1). This results in a +3,5K condenser outlet temperature penalisation under the assumption used for this simulation all year round.

Table 11: Underperformance of a HFC installation

	1 year	10 years	15 years
Percentage difference vs. baseline [%]	+ 11,7%	+ 11,7%	+ 11,7%
Additional energy [kWh]	43360	433603	650404
Additional cost [€]	7805	78048	117073
Additional CO ₂ emission [tons]	14,7	146,6	219,8

CURVE OF IMPACTS ON A REFRIGERATION SYSTEM WITH DIFFERENT UNDERPERFORMANCE RATES

The above case studies demonstrate condenser and gas cooler underperformance based on the most poorly performing systems analysed by Eurovent Certita Certification within the scope of the simulations conducted. To provide a broader view of the impact on refrigeration systems across different underperforming rates, the following scenarios were simulated for comparative and illustrative purposes:

S1 case: CO₂ refrigerant, -10% penalisation= +0,5K condenser outlet temperature in trans-critical phase and +2,5K in sub-critical phase

S2 case: CO₂ refrigerant, -20% penalisation= +1K condenser outlet temperature in trans-critical phase and +3K in sub-critical phase

S3 case: CO₂ refrigerant, -30% penalisation= +1,5K condenser outlet temperature in trans-critical phase and +3,5K in sub-critical phase

S4 case: R448a refrigerant, -10% penalisation= +2,5K condenser outlet temperature all year round

S5 case: R448a refrigerant, -20% penalisation= +3K condenser outlet temperature all year round

S6 case: R448a refrigerant, -30% penalisation= +3,5K condenser outlet temperature all year round

Results were simulated across 1 year, 10 years and 15 years to mimic the lifecycle of HFC condensers and CO₂ gas coolers.

Figure 4: Percentage difference vs baseline

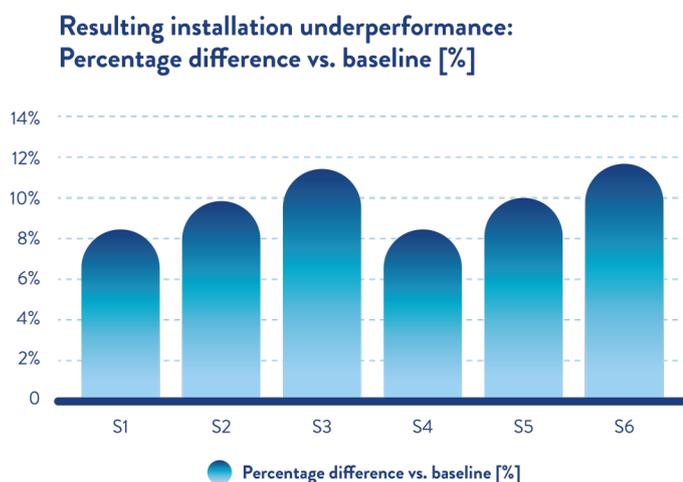


Table 12: Underperformance at varying conditions over a 1-year period.

1 year	S1	S2	S3	S4	S5	S6
Percentage difference vs. baseline [%]	+ 8,1%	+ 9,8%	+ 11,4%	+ 8,5%	+ 10,1%	+ 11,7%
Additional energy [kWh]	29776	36448	43301	30214	36707	43360
Additional cost [€]	5360	6561	7794	5438	6607	7805
Additional CO ₂ emission [tons]	10,1	12,3	14,6	10,2	12,4	14,7

Figure 5: Impact of underperformance over a 1-year period

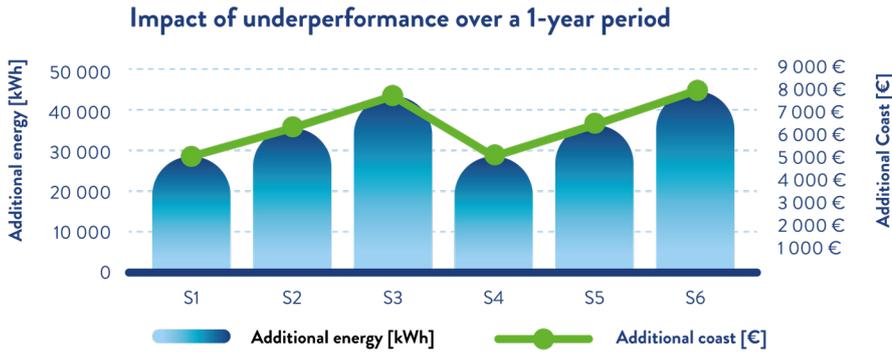


Table 13: Underperformance at varying conditions over a 10-year period.

10 years	S1	S2	S3	S4	S5	S6
Percentage difference vs. baseline	+ 8,1%	+ 9,8%	+ 11,4%	+ 8,5%	+ 10,1%	+ 11,7%
Additional energy [kWh]	297760	364479	433009	302138	367071	433603
Additional cost [€]	53597	65606	77942	54385	66073	78048
Additional CO ₂ emission [tons]	100,6	123,2	146,4	102,1	124,1	146,6

Figure 6: Impact over underperformance of a CO₂ gas cooler over a 10-year period

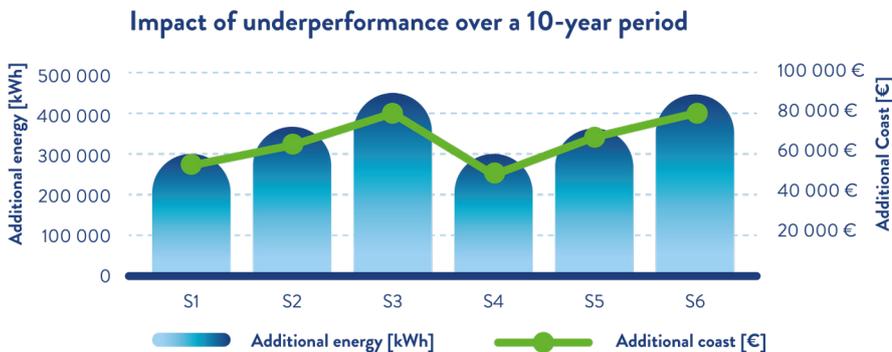


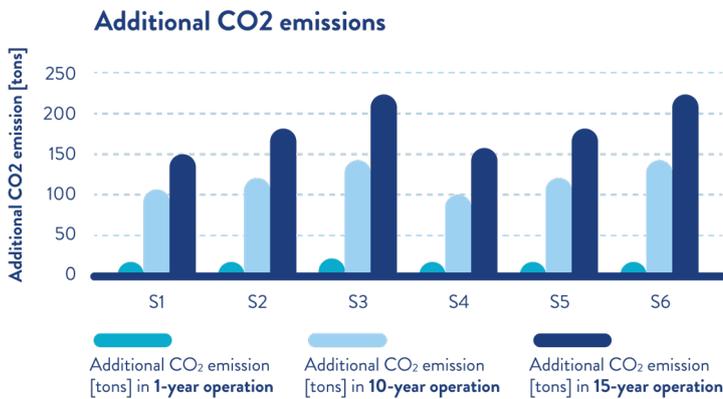
Table 14: Underperformance at varying conditions over a 15-year period.

15 years	S1	S2	S3	S4	S5	S6
Percentage difference vs. baseline	+ 8,1%	+ 9,8%	+ 11,4%	+ 8,5%	+ 10,1%	+ 11,7%
Additional energy [kWh]	446640	546719	649514	453207	550607	650404
Additional cost [€]	80395	98409	116912	81577	99109	117073
Additional CO ₂ emission [tons]	151	184,8	219,5	153,2	186,1	219,8

Figure 7: Impact of underperformance over a 15-year period



Figure 8: Additional CO₂ emissions



VALIDATION OF EUROVENT CERTITA CERTIFICATION SCHEME

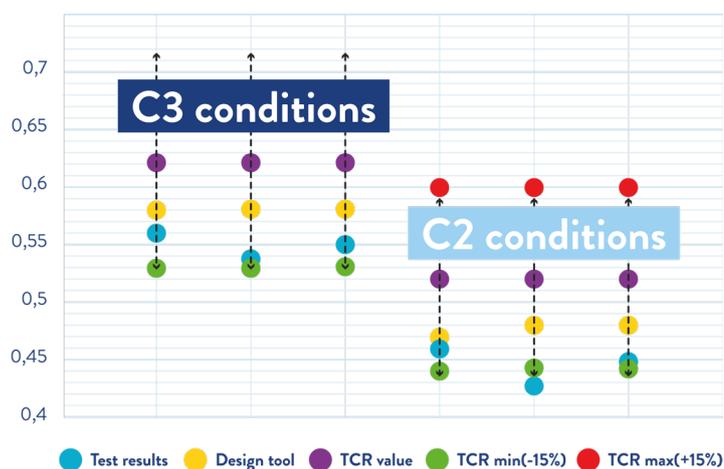
CORRECTION FACTORS

The heat transfer capacity of CO₂ gas coolers is a function of the system's operating conditions, depending on location, season, load, etc. Since it is almost impossible to test the product's performance covering all the possible operating points, proper correction factors have been defined to link common operating conditions to the capacity values declared in the standard one (ref. EN 327: 2014). These correction factors, whose values strongly diverge from 1 for many conditions, are intended to identify an indicative range of the capacity that the user must expect with respect to the standard value. Beside little deviations that can be expected according to the product design (e.g. tubes circuiting, fan speed, etc.), the validity to the correction factors is based on the thermophysical properties of CO₂ and it is always verified, regardless the product configuration.

These are the results of a deep technical analysis conducted by the HE manufacturers, in cooperation with third-party institutes, and have been validated through specific third-party laboratory tests.

The gas cooler test campaign included in this white paper also aimed to demonstrate the relevance of these correction factors. Since the conditions most commonly used in Central and Northern Europe are conditions C3 and C2 and crucially are also those where market data shows the most unrealistic performance, the analysis in this section will focus primarily on these two conditions. Figure 9 compares the outcome correction factors from different alternative approaches: test, calculation with a design tool and Eurovent Certita Certification's Technical Certification Rules for gas coolers.

Figure 9: Gas Coolers correction factors comparison



These results confirm the validity of the correction factors for the conditions C3 and C2 of the Eurovent Certita Certification TCR for gas coolers, as these correction factors are the guideline with a tolerance

of 15%. This means that even if performances of a manufacturer's gas coolers under market operating conditions depend on the circuiting of the units themselves, they are to be within the tolerance of 15% to be thermodynamically realistic.

Understanding operating conditions and correction factors

CO₂ is very sensitive to operating pressure and ambient conditions, which means systems require a unique testing process. To have a reference condition, Standard Conditions have been developed by manufacturers and industry stakeholders to provide a realistic test point, which lays down a common and technically meaningful benchmark for CO₂ gas cooler performance. Without Standard Conditions, every manufacturer could present data at different pressures, air inlet temperatures, or approach values making it impossible for specifiers to compare products reliably.

However, while the Standard Condition, SC20, provides an excellent condition for laboratory testing in transcritical mode, it is not representative of operating conditions across the whole market. In response, to optimise the test cost that may be generated by several possibilities of market operating conditions, Eurovent Certita Certification in collaboration with key Gas Cooler manufacturers, set up the correction factors based on the physics to allow transitioning from the standard transcritical condition to market conditions. These correction factors were developed to simulate the efficiency of CO₂ units across different climate zones. To do so, these correction factors are applied to the results of laboratory tests at SC20 to ascertain expected performance across different market conditions.

The definition of transcritical and subcritical operating conditions can be found in table 2 and table 3 in this document.

THE ROLE OF EUROVENT CERTIFIED PERFORMANCE

The product certification programmes offered by Eurovent Certita Certification reduce risk and build trust between industry stakeholders, by independently and impartially verifying the accuracy of manufacturers' data. Manufacturers voluntarily submit their products for evaluation, knowing that equipment will have to pass numerous checkpoints to be certified.

The Eurovent Certified Performance programme for Heat Exchangers (HE) verifies the performance of CO₂ Gas Coolers, Direct Expansion (Dx) Air Coolers using HFC, Dx Air Coolers using CO₂, Air Cooled Condensers and Dry Coolers. The programme verifies data through a robust certification process,

Find out more about the Eurovent
Certified Performance programme for
Heat Exchangers (HE) at
www.eurovent-certification.com



including:

- Independent laboratory tests to verify performance across nine (9) market conditions
- Factory audits to ensure the products coming off the production line are the same as those tested in the laboratory
- Software audits to ensure certified values are used in product selection software
- Full analysis and validation of all supplied information to ensure correct use of data, (including marketing materials).
- Surveillance process to ensure products continue to conform with certified values.

Eurovent Certification also ensures all products within the programme:

- Are evaluated according to the same criteria
- Have results expressed in the same unit of measurement, regardless of the country where the products are manufactured or marketed
- Go through exactly the same certification, auditing and surveillance process
- Are impartiality assessed. Manufacturers and laboratories have no direct contact, keeping the process clear of any bias
- Plus, for products with components manufactured across multiple sites (sometimes in different countries), all must reach Eurovent Certified Certification standards.

The comprehensive certification process presents accurate results consistently – allowing for fair and direct comparison – helping decision makers cut through uncertainty.

Improving certification practices

The test campaign process – used to select the CO₂ gas coolers to be evaluated in this white paper – has helped to improve the Heat Exchanger programme. The software used for the design tool simulation has now been incorporated in the certification regime to identify models to be put forward for laboratory tests. It has helped make certification more efficient by streamlining product selection and pinpointing the units required for physical tests.

ROBUST AND TRANSPARENT CERTIFICATION PROGRAMMES

Certification is earned not bought

Every Eurovent certified product has earned its certified status. Products undergoing the initial Eurovent Certified Performance certification process must pass all tests to be certified. Additionally, products that have successfully gained certification must undergo regular compliance checks. This ensures that data remains accurate while the product is certified.

What happens if a product fails a test?

While there is a tolerance for very minor deviations between declared performance and laboratory test results, anything outside of those tolerances will constitute a failed test. Test failures are dealt with fairly,

but robustly.

If a product fails a test, the participant has three choices:

- They accept the first test result and rerate their products according to the test result.
- They can ask for a second test of the same unit.
- Or they can ask for a second test of a new unit.

Participants can only re-test once. In serious cases, test failures can result in certificate suspension.

In cases where the rerate result is accepted, the participant has a defined deadline to update their data according to the test results. Eurovent Certita Certification will regularly check that the rerates have been applied correctly and will issue penalty tests to ensure data integrity.

Full, transparent information on accepted tolerances can be found in the Technical Certification Rules for each certification programme.

For manufacturers, certification is a valuable tool to build customer trust. As performance is stringently verified by an independent body, certification creates confidence and differentiates products from others that are uncertified.

Full range of certified refrigeration products

As Eurovent Certita Certification certifies a range of refrigeration equipment, decision makers can also access certified data for:

- Process chillers
- Cooling and heating coils
- Cooling towers
- Drift eliminators
- Evaporative cooling
- IT cooling units
- Refrigerated display cabinets
- Heat recovery systems with intermediate heat transfer medium.

Look for the logo to identify
Eurovent Certified products



Search for certified refrigeration
products now at
www.eurovent-certification.com



REAL DATA – REAL PERFORMANCE

CONCLUSION

Product and whole system underperformance continues to be a threat within the industry. Eurovent Certita Certification's investigations have revealed that while there are uncertified products on the market that perform as advertised, this was the case for only 1 in 5 randomly selected uncertified CO₂ gas coolers. This indicates the risk attached to choosing an uncertified model. Furthermore, laboratory tests revealed that the worst performing unit had a significant gap of 53% between claimed and measured performance at Condition 4 (C2 in Eurovent Certita Certification's TCR).

With a previous study on HFC condensers revealing a 32% underperformance, Eurovent Certita Certification was able to calculate the real consequences of heat rejection equipment underperformance for a CO₂ and a HFC supermarket application. For both systems, inefficient heat rejection components result in over 43,000 kWh extra energy use annually, costing more than €7,800 a year and adding at least 14.7 tonnes of CO₂ emissions under the assumptions applied in case studies. Over a 15-year lifespan, this equated to an additional 650,000 kWh in energy consumed, at a cost in excess of €117,000 and at least an additional 219 tonnes of CO₂ emissions based on the same case study assumptions. This is without considering the additional impact on system reliability and longevity, as components work harder to meet the required heat rejection under these simulated conditions. In short, the analysis demonstrated that the underperformance went further than the unit alone, affecting the operation of the entire refrigeration system.

The test campaign also validated Eurovent Certita Certification's use of correction factors, with the results for laboratory tests and design simulations across a range of conditions falling within the 15% tolerance allowed within the Heat Exchangers TCR. The results showed the crucial nature of applying correction factors – especially for products installed in Central and Northern Europe – where the deviations in claimed and measured performance at C3 and C2 will have the biggest impact according to the scenarios analysed.

To conclude, decision makers, HVAC professionals and end users need to look beyond the brochure and marketing hype when making product purchase decisions and instead trust independently verified performance data where available. Eurovent Certified Performance offers truth and transparency in product performance for all industry stakeholders.



MANUFACTURERS

Eurovent Certified Performance programmes build customer confidence and demonstrate your commitment to performance and trust. Find out more about certification today at apply@eurovent-certification.com



SPECIFIERS, DESIGNERS AND INSTALLERS

Reduce the risk of underperformance – always use certified products. Look for the logo or access the Eurovent Certified Product Directory for free at www.eurovent-certification.com



END USERS

When it's time to replace equipment, insist on certified products, for low carbon systems that won't cost the earth. Look for the logo or find out more on our website at www.eurovent-certification.com

WE BUILD TRUST

Eurovent Certita Certification has been certifying products since 1994 and is recognised as a world leader in voluntary, third-party product performance certification, for the HVACR industry. Its partner laboratories and agencies are located across the globe and are regularly assessed according to ISO/IEC 17025. All have been carefully selected for their ability to test products to each programme scope and exacting standards. For a full list of partner laboratories please see www.eurovent-certification.com

Eurovent Certita Certification is an accredited certification body, recognised by Cofrac with accreditation number 5-0517. The scope of accreditation is available on www.cofrac.fr.



We build trust.

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