Compressor Performance and Efficiency

COMPARISON TEST

Unicla

Advanced compressor technology for the world

200 Series

Test No. 2018007

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Introduction

This test was instigated in response to ongoing comments from Unicla customers and end users that Unicla 170 and 200 series compressors were achieving better than expected results when operating in systems, and for reasons unknown or explained in Unicla documentation, outperforming other compressors of similar capacity in the market.

Additionally, Unicla engineers had not previously validated this feedback and the end users making these claims had been unable to verify their statements with any data or test results. Unicla engineers had also heard many anecdotes from refrigeration system customers that "the system runs much better and more efficiently".

The commonality in these statements appears to be related to comparisons between Unicla 10-cylinder swashplate technology, with its separate crankcase and cylinder housing, and other six- and 10-cylinder swashplate compressors with common crankcase and cylinder housings.

Unicla has conducted this test to provide some supporting facts to these claims and anecdotes.

Purpose

The purpose of this test is to compare Unicla 10-cylinder swashplate technology to another common 10-cylinder swashplate type compressor of similar capacity. The Unicla compressor chosen is a **UXF200**, and the alternative 10-cylinder is a genuine "**Type 21**" compressor.

The system application used is a modern direct drive refrigeration unit operating with refrigerant R404a. The high-compression, low-temperature characteristics of this system and R404a refrigerant allow for an acute study and comparison of results between compressors.

The volumetric efficiency, capacity, power consumption, coefficient of performance and the required cost for running these compressors is measured, calculated and compared.

Summary

1. The key finding of this test was that the **Unicla UXF200 consumed 16 per cent less power** than the Type 21 compressor in all rev ranges.

2. This lower power consumption also led to a better coefficient of performance (COP) in all rev ranges. Please see Graph 2, which shows **a 20 per cent COP improvement.**

3. **Running costs are also considerably lower for the UXF200.** A cost-effectiveness comparison conducted at identical cooling capacity conditions is shown in Table 3. As an example, the mid-range operating conditions of both compressors at an equivalent capacity of 10 kW and rev ranges of 1775 (UXF200) and 1600 rpm (Type 21) reveals **annual savings of €955 when operating on market value electricity power, and €886 operating on diesel power.** Table 3 shows that for all other capacity and rpm conditions, the UXF200 also yields significant savings.

4. The volumetric efficiency (VE) of both compressors is very similar. In various rpm conditions, the **VE difference was less than 3 per cent.**

5. Due to an extra 14.30 cc of volumetric capacity over the UXF200, the Type 21 compressor has higher cooling capacity in all rev ranges, which equates to 7-10 per cent in lower rev ranges and up to 15 per cent in higher ranges. Therefore the rpm/capacity correction factor for the UXF200 is approximately 10-12 per cent across all ranges. As mentioned above, 10 kW in the test was achieved by the Type 21 at 1600 rpm, and the UXF200 just 175 rpm higher.

6. Although the reason for the UXF200's enhanced COP and lower power consumption is not fully known at his stage, it is suspected to be related to **differences in the fundamental working assemblies and manufacturing techniques** of the two compressors. The Unicla UXF200 has a separate solid steel cylinder housing that enables **high-precision matching of pistons to chambers during the production process.** As a result, there is **minimal tolerance stack between components** once the compressor is assembled and the chance of tight operation is minimised. As a secondary check for this point, all Unicla compressors are torque-tested at the end of the production process.

Methodology

The system used for this test was a Carrier Citimax 700 unit.

The Unicla UXF200 was new from its box and packaging as supplied by the factory.

The Type 21 was new from its box and packaging as supplied by the Australian agent.

Volumetric efficiency and capacity were calculated under the following conditions:

- The actual flow of the refrigerant was measured in two different rpm conditions (approximately 1200 and 1750) as shown in *Table 1*.
- Compressor discharge and suction pressure were maintained at a constant 4.5 bar at the evaporator outlet and 20 bar at the compressor outlet.
- Volumetric efficiency was used to calculate compressor capacity in kJ/s.
- Constant superheat and subcooling temperatures of 0 and 5 °C were used to calculate the capacity.

Power consumption was measured and analysed under identical conditions.

The capacity and power consumption shown in *Graph 1* was developed using the conversion factor published by the manufacturer of the Type 21 compressor, and the factor calculated by Unicla for the UXF200,

The running cost calculations shown in *Table 3* are based on the following conditions:

- The system operation cycle is 12 hours a day, six days a week (a total of 3744 hours per year)
- The electric rate is 30 Euro cents per kWh
- The diesel rate is 1.20 Euro per litre

Volumetric efficiency

Conditions in the table below were maintained.

	rpm	Compressor discharge pressure	Compressor suction pressure	Flow (l/min)	Efficiency (%)
UXF200	1214	20.1 (bar)	4.5 (bar)	154.0	63.5
	1752	201 (bar)	4.5 (bar)	186.5	53.5
Type 21	1214	20.1 (bar)	4.5 (bar)	170.5	65.0
	1731	20.1 (bar)	4.5 (bar)	210.7	56.0

Table 1: Testing conditions and volumetric efficiency results

Cooling capacity and power consumption

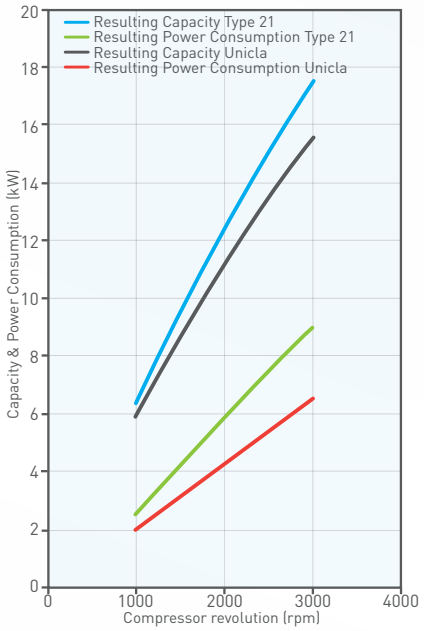
Using the above-mentioned VE in *Table 1*, the capacity of the compressors calculated is shown in *Graph 1*.

As expected, the 214.7 cc Type 21 compressor had slightly higher cooling capacity and system flow rate than the 200.3 cc UXF200 due to its higher volumetric capacity. However, in lower rpm ranges this difference was minimal (7 to 10 per cent). *Table 2* shows the capacity of the two compressors in various rpm conditions.

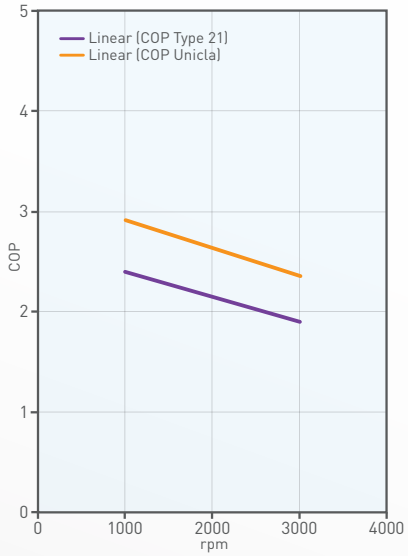
The power consumption and the coefficient of performance were also measured and calculated (*Table 2*). The results show that the UXF200 works with approximately 16 per cent higher efficiency across all rev ranges (*Graph 2*).

	Unicla UXF200	Type 21	Unicla UXF200	Type 21
rpm	Capacity (kW)		Power consumption (kW)	
1000	5.9	6.4	2.0	2.5
1200	7.0	7.6	2.4	3.2
1500	8.6	9.4	3.1	4.2
2000	11.2	12.4	4.3	5.9

Table 2: Capacity and Power Consumption



Graph 1: Unicla UXF200 and Type 21 cooling capacity and power consumption at 4.5 bar suction line pressure and 20.1 bar discharge line pressure



Graph 2: Unicla UXF200 and Type 21 coefficient of performance (COP)

Running costs

In order to compare running costs, the power consumption of each compressor was calculated under identical cooling capacity conditions.

	Unicla UXF200	Type 21	Saving per year using UXF200 (Euro)
rpm	1225	1125	
Cooling capacity kW	7.16	7.17	
Power consumption kW	2.5	2.9	
Running cost (electric) Euro	2808	3257	€449
Running cost (diesel) Euro	4223	4453	€230
rpm	1575	1425	
Cooling capacity kW	9.04	9.03	
Power consumption kW	3.3	4.0	
Running cost (electric) Euro	3707	4493	€786
Running cost (diesel) Euro	4748	5391	€642
rpm	1775	1600	
Cooling capacity kW	10.07	10.08	
Power consumption kW	3.75	4.6	
Running cost (electric) Euro	4212	5167	€955
Running cost (diesel) Euro	5146	6032	€886
rpm	1925	1725	
Cooling capacity kW	10.82	10.83	
Power consumption kW	4.1	5.0	
Running cost (electric) Euro	4605	5616	€1011
Running cost (diesel) Euro	5494	6486	€993
rpm	2075	1850	
Cooling capacity kW	11.55	11.55	
Power consumption kW	4.4	5.4	
Running cost (electric) Euro	4942	6065	€1123
Running cost (diesel) Euro	5812	6950	€1138

Table 3: Cost calculated for a system working 12 hours a day, six days a week (3744 hours per year)

Electric cost: 30 Euro cents per kWh
Diesel cost: 1.20 Euro per litre

Appendix: Test rig

Image 1: Motor bench

Image 2: Motor bench and Citimax 700 condenser unit in thermal test chamber

Image 3: Citimax 700 evaporator unit in thermal test chamber

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Other references:
Unicla General Service Information (Cat.No.B0901)
Unicla Compressor Selection Criteria (Cat.No.B0902)