

Test report

Test on VGE Eco Air M11 heat pump according to UNI EN14511:2022 and UNI EN 14825:2022 for medium temperature application

Institute for Renewable Energy
Heat Pump Lab

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Report n.

24/023_2.v1

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Report n. 24/023_2.v1

T117-HPL Test report_r2, 04/08/2023

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This report no. 24/023_2.v1 of the 16/04/2024 cancels and replaces the previous report no. 24/023_2 of the 15/04/24..

The applied corrections are:

- Added “Summary of results”, page 3;

The corrections are also identified with a sidebar.

Summary of results

Seasonal heating efficiency according to UNI EN 14825:2022.

| | | | | | |
|--|--------------------------|--|--------------|--------|------|
| Model | VGE Eco Air M11-F3.R32.0 | | | | |
| Serial number | PPAL04022092927 | | | | |
| Function | | | Reversible | | |
| Typology | | | Monobloc A/W | | |
| Climate | | | Average | | U |
| Temperature | | | Medium | | |
| Rated heat output | P_{rated} | | kW | 10 | |
| Seasonal space heating energy efficiency | η_{SH} | | % | 128.9% | 2.6% |
| Seasonal COP | SCOP | | | 3.30 | 0.07 |
| Seasonal COP in active mode | SCOPon | | | 3.30 | 0.07 |
| Net Seasonal COP | SCOPnet | | | 3.33 | 0.07 |

Conformity verification to class A++ of Table 1 of reg. EU 811/2013

| ID Sample | Seasonal heating efficiency / % | PFA* / % | Conformity status |
|--|---------------------------------|----------|-------------------|
| VGE Eco Air M11-F3.R32.0 s.n. PPAL04022092927 | 128.9 | 1% | PASS |

1 Test sample

On 20/03/2024 the Customer delivered nr. 2 monobloc air-to-water heat pump. The laboratory has selected the unit as identified below:

Table 1. Test sample¹

| | |
|--|--|
| Monobloc unit | |
| Manufacturer | VGE |
| Type | Monobloc reversible air-to-water heat pump |
| Model | VGE Eco Air M11-F3.R32.0 |
| Serial | PPAL04022092927 |
| Production year | 2022 |
| Power supply | 400V/3Ph/50-60Hz |
| Refrigerant | |
| Type of refrigerant | R32 |
| Refrigerant charge | 1600 g |
| Working fluid (provided by Laboratory) | Water |

The laboratory proceeded to identify the sample with the identifier 24/023_M11_unit1.

Test results apply to the sample as received.

2 Performed tests

The requested test has been assigned the following order number 24/023. The following tests were carried out.

The tests were executed in different days according to the following Table.

Table 2. Tests.

| Denomination | Standard | Date | Point | Identification number of test |
|--|---------------------|------------|-------|-------------------------------|
| Preliminary activities Unit installation | UNI EN 14511-3:2022 | 22/03/2024 | N.A. | N.A. |
| ACTIVITY 1 Nominal performance in heating mode | UNI EN 14511-3:2022 | 26/03/2024 | 7/55 | 2123 |
| ACTIVITY 2 Seasonal performance in heating mode | UNI EN 14825:2022 | 03/04/2024 | A | 2129 |
| | | 02/04/2024 | B | 2128 |
| | | 26/03/2024 | C | 2123 |
| | | 25/03/2024 | D | 2122 |
| | | 28/03/2024 | E | 2126 |

2.1 Activity 1 – Test in heating mode according to UNI EN 14511-3:2022

For the measurement of the heating capacity the laboratory applied the direct method (liquid enthalpy).

The heating capacity is calculated according to the following equation:

$$\Phi_{thi} = \frac{q \cdot \rho \cdot (c_{p,out} \cdot T_{out} - c_{p,in} \cdot T_{in})}{3600}$$

Equation 1

Where:

- Φ_{thi} is the heating capacity, expressed in kW;
- q is the volumetric flow of the internal heat exchanger, expressed in m³/h;
- ρ is the density, expressed in kg/m³;
- c_p is the specific heat, expressed in J/kgK;

- T is the temperature, expressed in °C.

The thermodynamic properties of the water are defined as a function of the temperature according to the tables of the "Perry's Chemical Engineering Handbook, 7th Edition, 1997".

The heating capacity and the power input are corrected to consider the presence of the liquid pumps and the fan.

The corrections for the non-integrated liquid pumps are:

$$corr_{P_{th}} = q \cdot \Delta p_i \cdot \frac{1 - \eta}{\eta}$$

Equation 2

$$corr_{P_{el}} = \frac{q \cdot \Delta p_i}{\eta}$$

Equation 3

where:

- q is the volumetric flow of the internal heat exchanger, expressed in m³/h;
- Δp_i is the internal static pressure difference, expressed in Pascal;
- η is the efficiency of the pump calculated according to Annex F of UNI EN 14511-3:2022.

The coefficient of performance is calculated considering the corrections:

$$COP = \frac{P_{th} + corr_{P_{th}}}{P_T + corr_{P_{el-pump}}}$$

Equation 4

2.2 Activity 2 – Test in heating mode according to UNI EN 14825:2022

The seasonal heating efficiency is calculated according to EN 14825:2022. The seasonal efficiency in heating, expressed in % is calculated according to:

$$\eta_{s,h} = \frac{1}{CC} \cdot SCOP - \sum F(i)$$

Equazione 5

$$SCOP = \frac{Q_H}{Q_{HE}}$$

Equazione 6

Where:

- CC is the coefficient for electricity generation efficiency, equal to 2.5;
- SCOP is the seasonal COP;
- F(i) are the correction factors, F(1) = 3% for the control temperature, (F2) = 5% for the water (or brine) source;
- Q_H is the reference annual heating demand, expressed in kWh;
- Q_{HE} is the annual energy consumption, expressed in kWh.

The reference annual heating demand is calculated according to:

$$Q_H = P_{design,h} \cdot H_{HE}$$

Equation 7

Where:

- $P_{design,h}$ is the design load, in kW;
- H_{HE} is the equivalent active mode hours for heating; defined in the Annex B of the standard.

The annual energy consumption is calculated as:

$$Q_{HE} = \frac{Q_H}{SCOP_{on}} + H_{TO} \cdot P_{TO} + H_{SB} \cdot P_{SB} + H_{CK} \cdot P_{CK} + H_{OFF} \cdot P_{OFF}$$

Equation 8

Where:

- Q_H is the reference annual heating demand, expressed in kWh;
- H_{TO} , H_{SB} , H_{CK} , H_{OFF} are the number of hours in the thermostat off mode, standby mode, crankcase heater mode e off mode as specified in the Annex B of the standard;
- P_{TO} , P_{SB} , P_{CK} , P_{OFF} are the power inputs, expressed in kW;
- $SCOP_{on}$ is the seasonal COP in active mode, expressed in kWh/kWh.

The seasonal COP in active mode is calculated according to:

$$SCOP_{on} = \frac{\sum_{j=1}^n h_j \cdot [P_h(T_j)]}{\sum_{j=1}^n h_j \cdot \left[\frac{P_h(T_j) - elbu(T_j)}{COP_{bin}(T_j)} + elbu(T_j) \right]}$$

Equation 9

$$SCOP_{net} = \frac{\sum_{j=1}^n h_j \cdot [P_h(T_j) - elbu(T_j)]}{\sum_{j=1}^n h_j \cdot \left[\frac{P_h(T_j) - elbu(T_j)}{COP_{bin}(T_j)} \right]}$$

Equation 10

Where:

- T_j is the bin temperature, expressed in °C;
- j is the number of bin;

- n is the total number of bins;
- $Ph(Tj)$ is the heating load at the Tj temperature of the j -th bin, expressed in kW;
- hj is the number of hours of the j -th bin at the temperature Tj ;
- $COP_{bin}(Tj)$ is the COP of the j -th bin at the temperature Tj ;
- $elbu(Tj)$ is the backup consumption of the j -th bin at the temperature Tj .

The values of j , Tj , hj are defined in the Annex B of the standard.

The load of the j -th bin, $Ph(Tj)$ is calculated as part load condition of the design capacity:

$$P_h = P_{design,h} \cdot \frac{T_j - 16}{T_{design,h} - 16} \quad \text{Equation 11}$$

where:

- $T_{design,h}$ is the design temperature (-10°C for the average climate);
- Tj is the temperature of the j -th bin, in °C;
- $P_{design,h}$ is the design load, in kW;

The values of COP and capacity are defined for each bin by interpolation of the tested points defined in EN14825. The part loads are obtained with a tolerance of $\pm 10\%$ by modulating the compressor capacity. The COP_{bin} is calculated according to:

$$COP_{bin} = COP_d \cdot \frac{CR}{C_d \cdot CR + (1 - C_d)} \quad \text{Equation 12}$$

where:

- COP_d is the declared COP calculated from the part load measurements in the conditions A, B, C, D, E;
- CR is the ratio between the part load capacity and the declared capacity;
- C_d is the degradation coefficient (applied if $CR < 1$), C_d is calculated for each point.

3 Test equipment

The tests have been performed using the following instruments with valid calibration state.

Table 3. Test equipment.

| Description | ID |
|--|--|
| Laboratory HPL Monitoring and Control System | AS10002 |
| Air temperature and humidity E+E Elektronik 211 Temperature: -40:60°C Humidity: 0-100% | T.TC1:AS01 - ID01134 T.TC1:AS02 - ID01130 T.TC1:AS03 - ID01131 T.TC1:AS04 - ID01141 |
| Temperature - PT100 4 wires – class 1/5 DIN -40:100°C | W.SS3:TM01 – ID02045 W.SS3:TM02 – ID02046 |
| Water differential pressure Endress Hauser Deltabar PMD55 pressure 0-500 mbar | W.US1:PM01 – ID01172 |
| Water Flow rate Siemens SITRANS MAG 1100 flow 0-10 m ³ /h | W.SS3:FM01– ID02064 |
| Power Analyser: Vitretek PA900 3x SD module | ID02740 ID03036 + ID3037 + ID3038 |
| Refrigerant pressure – Huba 520 0 - 50 bar rel | T.TC1:PM10 – ID3090 |
| Refrigerant temperature - PT100 4 wires – class 1/3 DIN -40:150°C | T.TC1:TM04 – ID3079 T.TC1:TM06 – ID3081 T.TC1:TM09 – ID3084 |
| Ambient pressure GHM GROUP – Greisinger GMUD-MP – S | E.A11:PM01 – ID02070 |

The unit was installed in the chamber A1 of the Laboratory.



Figure 1. Installation of the test sample.

4 Test Results

4.1 Activity 1 – Heating mode A/W unit according to UNI EN 14511-3:2022

The following table presents the performance according to UNI EN 14511-3:2022 for the nominal point and for the part load conditions as defined by UNI EN 14825:2022.

The measurement of the condensation pressure was not available due to the impossibility of installing the sensor.

Table 4. Test results according to UNI EN 14511-3:2022 for A/W units in heating mode.

| | | Nom | E | A | B | C | D |
|-----------------------------------|-------------------|-------|--------|-------|-------|-------|-------|
| Outdoor heat exchanger | | | | | | | |
| Air temperature, dry bulb | °C | 7.09 | -9.85 | -6.84 | 2.19 | 7.15 | 12.01 |
| Air temperature, wet bulb | °C | 6.99 | -10.48 | -7.78 | 0.99 | 6.30 | 11.15 |
| Relative humidity | % | 89.33 | 81.01 | 76.67 | 80.95 | 89.90 | 90.47 |
| Atmospheric pressure | Pa | 97446 | 97277 | 98622 | 98398 | 97717 | 98014 |
| Indoor heat exchanger | | | | | | | |
| Air temperature, dry bulb | °C | 7.09 | -9.79 | -6.78 | 2.30 | 7.15 | 12.01 |
| Liquid inlet temperature | °C | 47.01 | 49.49 | 45.31 | 37.45 | 32.66 | 26.18 |
| Liquid outlet temperature | °C | 55.12 | 55.00 | 51.85 | 42.00 | 36.06 | 29.99 |
| Temperature difference | K | 8.11 | 5.51 | 6.54 | 4.55 | 3.40 | 3.81 |
| Flow rate | m ³ /h | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| Static pressure difference | mbar | 71 | 70 | 71 | 72 | 74 | 75 |
| Total capacity | kW | 9.62 | 6.53 | 7.75 | 5.38 | 4.03 | 4.52 |
| Pump corrections | kW | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Electrical Quantities | | | | | | | |
| Voltage | V | 229.4 | 229.2 | 229.2 | 230.0 | 230.7 | 230.4 |
| Current | A | 5.57 | 6.90 | 5.88 | 2.95 | 1.73 | 1.56 |
| Total electrical power input | kW | 3.29 | 4.25 | 3.48 | 1.67 | 0.94 | 0.84 |
| Power input correction | kW | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Refrigerant circuit | | | | | | | |
| Compressor frequency ¹ | Hz | 70 | 90 | 85 | 35 | 30 | 30 |
| EEV Main ¹ | step | 300 | 200 | 112 | 92 | 110 | 130 |
| EEV Assistance ¹ | step | 46 | 120 | 100 | 50 | 20 | 30 |
| Fan ¹ | rpm | 550 | 900 | 900 | 600 | 550 | 850 |
| Condensing pressure | bar abs | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Evaporating pressure | bar abs | 7.9 | 4.9 | 4.2 | 6.6 | 8.7 | 9.6 |
| Discharge temperature | °C | 76.9 | 66.8 | 73.7 | 66.8 | 67.2 | 54.2 |
| Liquid temperature | °C | 50.4 | 48.9 | 45.8 | 38.6 | 33.9 | 27.8 |
| Bubble point temperature | °C | 1.3 | -12.3 | -15.3 | -4.5 | 4.0 | 10.0 |
| | | | | | | | |
| Effective electrical power input | kW | 3.31 | 4.26 | 3.49 | 1.69 | 0.95 | 0.86 |
| Effective capacity in heating | kW | 9.63 | 6.54 | 7.76 | 5.40 | 4.04 | 4.54 |
| COP | kW/kW | 2.91 | 1.53 | 2.22 | 3.20 | 4.23 | 5.30 |

4.2 Activity 2 – Heating mode A/W unit according to UNI EN 14825:2022

Table 5. Test results according to UNI EN 14825:2022.

| | | | | | | |
|---|-------------------------------------|--------------------------------|--------------|--------|------------|------|
| Model | | VGE Eco Air M11-F3.R32.0 | | | | |
| Serial number | | PPAL04022092927 | | | | |
| Function | | | | | Reversible | |
| Typology | | | | | A/W | |
| Climate | | | | | Average | U |
| Temperature | | | | | Medium | |
| Rated heat output | | P_{rated} | kW | 10 | | |
| Seasonal space heating energy efficiency | | η_{SH} | % | 128.9% | 2.6% | |
| Seasonal COP | | SCOP | | 3.30 | 0.07 | |
| Seasonal COP in active mode | | SCOPon | | 3.30 | 0.07 | |
| Seasonal COP net | | SCOPnet | | 3.33 | 0.07 | |
| Design temperature | | $T_{designh}$ | °C | -10 | | |
| Bivalent temperature | | T_{biv} | °C | -7 | | |
| Operation limit temperature | | TOL | °C | -10 | | |
| Declared capacity for heating at indoor conditions 20°C and outdoor temperature T_j | Climate (average, warmer or colder) | $T_j = -7^\circ\text{C}$ | P_{dh_A} | kW | 7.76 | 0.20 |
| | | $T_j = 2^\circ\text{C}$ | P_{dh_B} | kW | 5.40 | 0.19 |
| | | $T_j = 7^\circ\text{C}$ | P_{dh_C} | kW | 4.04 | 0.18 |
| | | $T_j = 12^\circ\text{C}$ | P_{dh_D} | kW | 4.54 | 0.18 |
| | | $T_j = \text{bivalent temp.}$ | P_{dh_F} | kW | 7.76 | 0.20 |
| | | $T_j = \text{operation limit}$ | P_{dh_E} | kW | 6.54 | 0.19 |
| Declared coefficient of performance for heating at indoor conditions 20°C and outdoor temperature T_j | | $T_j = -7^\circ\text{C}$ | COP_{d_A} | - | 2.22 | 0.03 |
| | | $T_j = 2^\circ\text{C}$ | COP_{d_B} | - | 3.20 | 0.06 |
| | | $T_j = 7^\circ\text{C}$ | COP_{d_C} | - | 4.23 | 0.10 |
| | | $T_j = 12^\circ\text{C}$ | COP_{d_D} | - | 5.30 | 0.11 |
| | | $T_j = \text{bivalent temp.}$ | COP_{d_F} | - | 2.22 | 0.03 |
| | | $T_j = \text{operation limit}$ | COP_{d_E} | - | 1.53 | 0.02 |
| Degradation coefficient | | $T_j = -7^\circ\text{C}$ | C_{dh_A} | - | 1.00 | |
| | | $T_j = 2^\circ\text{C}$ | C_{dh_B} | - | 0.99 | |
| | | $T_j = 7^\circ\text{C}$ | C_{dh_C} | - | 0.99 | |
| | | $T_j = 12^\circ\text{C}$ | C_{dh_D} | - | 0.99 | |
| | | $T_j = \text{bivalent temp.}$ | C_{dh_F} | - | 1.00 | |

| | | | | | |
|---|----------------------------------|------------------|-----|----------|----|
| | T _j = operation limit | Cdh_E | - | 1.00 | |
| Power input in modes other than active mode | Off mode | P _{OFF} | W | 11 | 1 |
| | Thermostat-off mode | P _{TO} | W | 0 | 4 |
| | Standby mode | P _{SB} | W | 11 | 1 |
| | Crankcase heater mode | P _{CK} | W | 0 | 0 |
| Supplementary heater | Type of energy input | | | Electric | |
| Other items | Capacity control | | | Variable | |
| | Annual energy | Q _H | kWh | 13360 | 0 |
| | | Q _{HE} | kWh | 6267 | 60 |
| Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. | | | | | |

5 Measurement Uncertainty

The uncertainty values of the results are expressed with a level of confidence of approximately 95% using a coverage factor k=2, as indicated in the Table.

Table 6. Uncertainty values of measurements

| Measurements | Uncertainty |
|---|-------------|
| Fluid inlet temperature | 0.10 °C |
| Fluid outlet temperature | 0.10 °C |
| Fluid Temperature difference | 0.14 K |
| Fluid volumetric flow rate | 1% |
| Fluid internal static pressure difference | 5 mbar |
| Environmental pressure | 100 Pa |
| Air temperature, dry bulb | 0.2 °C |
| Air temperature, wet bulb | 0.3 °C |
| Current | 0.2% |
| Voltage | 0.2% |
| Electric power | 0.5% |

6 Conformity verification

6.1 Applied decision parameters

The conformity verification considers the limits of Table 1 of reg. EU 811/2013 for the class A++

Table 1

Seasonal space heating energy efficiency classes of heaters, with the exception of low-temperature heat pumps and heat pump space heaters for low-temperature application

| Seasonal space heating energy efficiency class | Seasonal space heating energy efficiency η_s in % |
|--|--|
| A ⁺⁺⁺ | $\eta_s \geq 150$ |
| A ⁺⁺ | $125 \leq \eta_s < 150$ |
| A ⁺ | $98 \leq \eta_s < 125$ |
| A | $90 \leq \eta_s < 98$ |
| B | $82 \leq \eta_s < 90$ |
| C | $75 \leq \eta_s < 82$ |
| D | $36 \leq \eta_s < 75$ |
| E | $34 \leq \eta_s < 36$ |
| F | $30 \leq \eta_s < 34$ |
| G | $\eta_s < 30$ |

Source: Reg. EU 811/2013.

- Class A++
- Specification area: bilateral 125 - 150 %
- Accepted level of risk: 50%
- Decision rule: binary

6.2 Conformity statement

| ID Sample | Seasonal heating efficiency / % | PFA* / % | Conformity status |
|---|---------------------------------|----------|-------------------|
| VG E Eco Air M11-F3.R32.0 - s.n. PPAL04022092927 | 128.9 | 1% | PASS |

¹ Identify information provided by client, for which the Laboratory declines responsibility.

* PFA: Probability of False Acceptance