Verification Report
Ans Solvarme
Vacpipe Open End 15/180/30

Danish Technological Institute
Refrigeration and Heat Pump Technology
J.no. 1202
Test no. 1 – Type-test

Version 1.1

1. Table of Contents

1. Table of Contents 2
2. Introduction 3
   2.1. Name of Product 3
   2.2. Name and Contact of Vendor 3
   2.3. Name of Center/Verification Responsible 3
   2.4. Verification and Test Organization 3
   2.5. Expert Group 5
   2.6. Verification Process 5
3. Description of Technology 6
4. Product Description 6
5. Application and Performance Parameter Definitions 6
   5.1. Matrix/Matrices 6
   5.2. Target(s) 6
   5.3. Effects 6
   5.4. Performance Parameters for Verification 6
   5.5. Additional Parameters 7
6. Existing Data 7
   6.1. Summary of Existing Data 7
   6.2. Quality of Existing Data 7
   6.3. Accepted Existing Data 7
7. Test Plan Requirements 7
   7.1. Test Design 7
   7.2. Reference Analysis 7
   7.3. Data Management 8
   7.4. Quality Assurance 8
   7.5. Test Report 8
8. Evaluation 8
   8.1. Performance Parameter Summary 8
      8.1.1. Control Data 12
      8.1.2. Audits No audits were performed. 12
      8.1.3. Deviations 12
      8.1.4. Occupational Health and Environment 12
9. Liability Exclusion 12
10. Quality Assurance 13

Appendix 1 Terms and Definitions used in the Verification Protocol 14
Appendix 2 References 17
Appendix 3 Application and Performance Parameter Definitions 18
Appendix 7 Test Data Report 19

2. Introduction

Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology or a product for a specified application under defined conditions and quality assurance.

DANETV is a Danish center for the verification of environmental technology.

The verification is conducted according to the verification protocol for the specific technology tested in accordance with the test plan.

2.1. Name of Product

Ans Solvarme Vacpipe Open End 15/180/30

2.2. Name and Contact of Vendor

Ans Solvarme ApS

Palle Kerdil
Kertemindevej 160,
DK-5800 Nyborg
Phone: +45 65 36 12 19
Email: pk@anssolvarme.dk

2.3. Name of Center/Verification Responsible

Verification Center: Danish Technological Institute, Refrigeration and Heat Pump Technology, Building 2, Gregersensvej, DK-2630, Taastrup

Verification responsible:	Emil Jacobsen (EMJA), e-mail: emil.jacobsen@teknologisk.dk Phone: +45 7220 2323
Internal reviewer:	Bjarke Paaske, e-mail: bjarke.paaske@teknologisk.dk Phone: +45 7220 2037

2.4. Verification and Test Organization

The verification was conducted by Danish Technological Institute. The test organization is shown in Figure 1.

The verification was planned and conducted to meet the requirements of the ETV scheme which is currently being established by the European Union (EU ETV).

Verification and tests were performed by Danish Technological Institute in terms of DANETV under contract with Ans Solvarme.

The day to day operations of the verification and tests were coordinated and supervised by personnel from Danish Technological Institute with the participation of the vendor.

The subbody at the test center at Danish Technological Institute performed all testing during the verification.

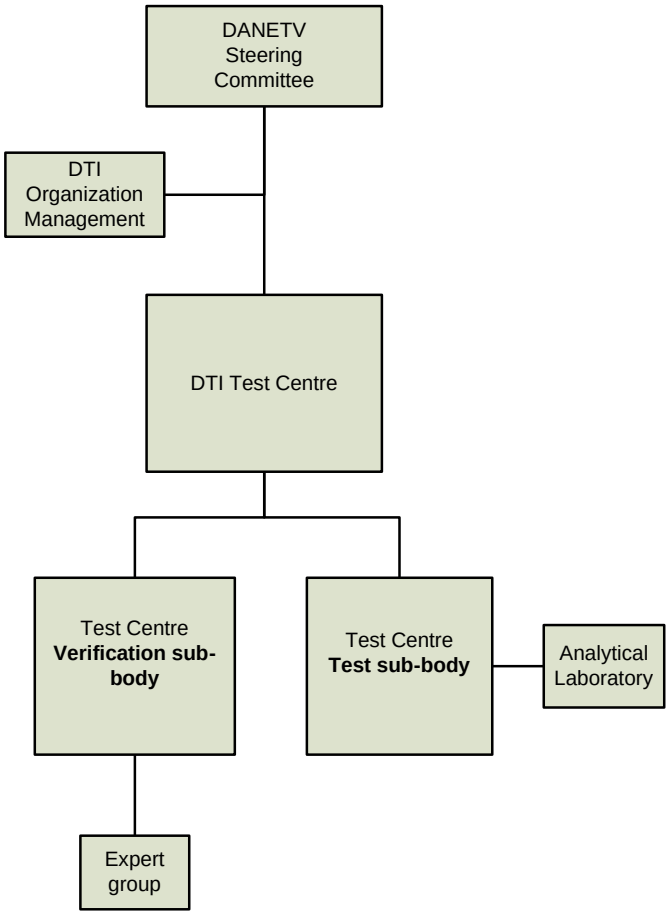

Figure 1 - Verification organization

Table 1 - Responsible personnel in the test organization:

Unit in test organization	**Responsible**
DTI Dan ETV steering committee member	Michael Poulsen
DTI organization management Energy and Climate division	Claus S. Poulsen
DTI Energy and Climate division Test Centre, Verification subbody	Emil Jacobsen
DTI Energy and Climate division Test Centre, Test subbody	Bjarke Paaske

2.5. Expert Group

The expert group assigned to this verification and responsible for the review of the verification plan and report documents includes:

Simon Furbo (SF), DTU Civil Engineering, phone +45 45251857, e-mail: sf@byg.dtu.dk

2.6. Verification Process

Verification and tests were conducted in two separate steps by the verification subbody and the test subbody, respectively.

The verification subbody is responsible for the preparation and compilation of the verification protocol and the verification report.

The test subbody is responsible for the test plan and the test report.

A DANETV verification is issued after the completion of the verification report.

The verification steps are shown in Figure 2.

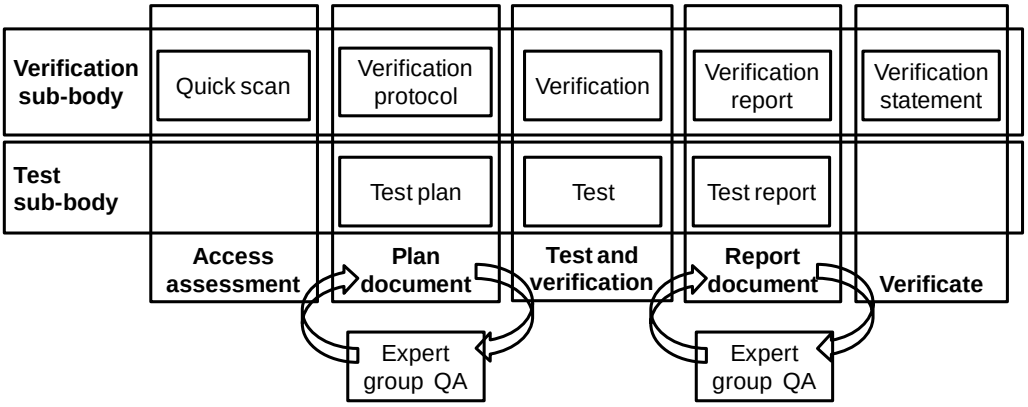

Figure 2 - Verification steps

3. Description of Technology

Solar Air Heaters

Open loop solar air heaters are characterized by simple devices which consist of three major parts:
1) Either a cabinet with a translucent cover or a fixture with a heat pipe array
2) A solar cell
3) A ventilator with or without a controller

When the solar cell powers the ventilator, cold outdoor air is driven through air channels which are irradiated whereby the air is heated. Subsequently, the heated air is channeled into a given summer house or garage whereby it is ventilated, heated, dried, or a combination of these.

If the air heater has a controller connected to the ventilator, the amount of air being driven through the air heater can typically be controlled and set-points for minimum or maximum start or stop temperatures can be adjusted.

4. Product Description

Ans Solvarme Vacpipe Open End 15/180/30

The Ans solvarme Vacpipe 15 is designed to deliver supplementary heating and ventilation to houses up to 90 m^2. The dimensions of the solar heater are 190 x 115 x 12 cm (H x W x D). The solar air heater consists of 15 vacuum absorber pipes mounted to an aluminum fixture with a top mounted solar panel powering a built-in ventilator.

5. Application and Performance Parameter Definitions

5.1. Matrix/Matrices

The matrix is the type of material which the product is intended for

- Residential houses up to 70 m^2

5.2. Target(s)

A target is defined as the property affected by the product

The target of the product is:

- Supplementary heating and ventilation

5.3. Effects

The effects are described as the way the target is affected

- Improved indoor climate in unheated humid buildings

5.4. Performance Parameters for Verification

The ranges of performance relevant for the application, as derived from Appendix 3, are presented below. These ranges are only used for planning the verification and testing.

In connection with the performance of the solar air heater, the following parameters are measured at different irradiation levels:

- Ambient temperature and air heater outlet temperatures, T_{amb} and T_{out}
- Air velocity of air through outlet channel, v_{out}
- Solar irradiance planar to the air heater, G

All parameters are measured every two seconds and with a tolerance according to EN 12975 - 2.

5.5. Additional Parameters

No additional parameters are required as part of the verification.

6. Existing Data

6.1. Summary of Existing Data

Previously, the vendor has made a test of the functioning and capabilities of the Ans Solvarme Vacpipe Open End 15/180/30.

6.2. Quality of Existing Data

Documentation of previous experiments exists, but these experiments were not intended as an actual type-test.

6.3. Accepted Existing Data

Data from previous experiments is not usable for this verification process.

7. Test Plan Requirements

7.1. Test Design

The DANETV solar air heater test is developed with the specific aim of making the test results as applicable, transparent and comprehensible as possible for the intended end user/homeowner/buyer.

Even though the EN 12975 standard for testing liquid heating collectors exits, this standard mainly deals with the robustness and thermal effectiveness of liquid heating collectors. Therefore, it is not applicable for open loop solar air heaters. Other previous tests of open loop air heaters, mainly centered on the effectiveness of the air heater, are very technical and not directly applicable for the intended end user/homeowner. Therefore, the DANETV test focuses on the verification of the vendor claims. The vendor claims are often related to energy savings, improved ventilation, improved indoor climate, or the like.

Furthermore, in order to give a better idea of how the solar air heater performs in an actual setting, a test rig has been built to simulate real running conditions comparable to those present when the air heater is mounted vertically on the side of a house or a garage. Establishing the actual performance characteristics of the air heater has a great advantage over laboratory tests with forced ventilation through the solar air heater as the fans are known to be very sensitive to pressure losses, both related to the heater itself and the downstream hot air channel. Tests performed on different models and makes are comparable by means of calculations based on data from the test rig and on regional climate data (design reference year data).

7.2. Reference Analysis

No references are used for this verification process.

7.3. Data Management

Data storage, transfer and control must be done in accordance with the requirements of the ETV Quality manual in order to enable full control and retrieval of documents and records.

7.4. Quality Assurance

The quality assurance of the tests includes control of the test system as well as control of the data quality and integrity. The test plan and the test report were subjected to review by the review group, see Figure 2.

7.5. Test Report

The test report follows the template of the TI Verification Centre Quality Manual with data and records from the presented tests.

8. Evaluation

8.1. Performance Parameter Summary

Test 1: Assessment of the User Manual

Intended use	
Product installation	OK
Product operation	OK
Function test	OK
Prevention of accidents	OK
Service and maintenance	OK

Test 2: Solar Air Heater Performance Test

Ventilation

The performance test showed that the Ans Solvarme Vacpipe Open End 15/180/30 starts ventilating at an irradiance of 33 W/m^2 and it has a correlation as shown in Figure 3.

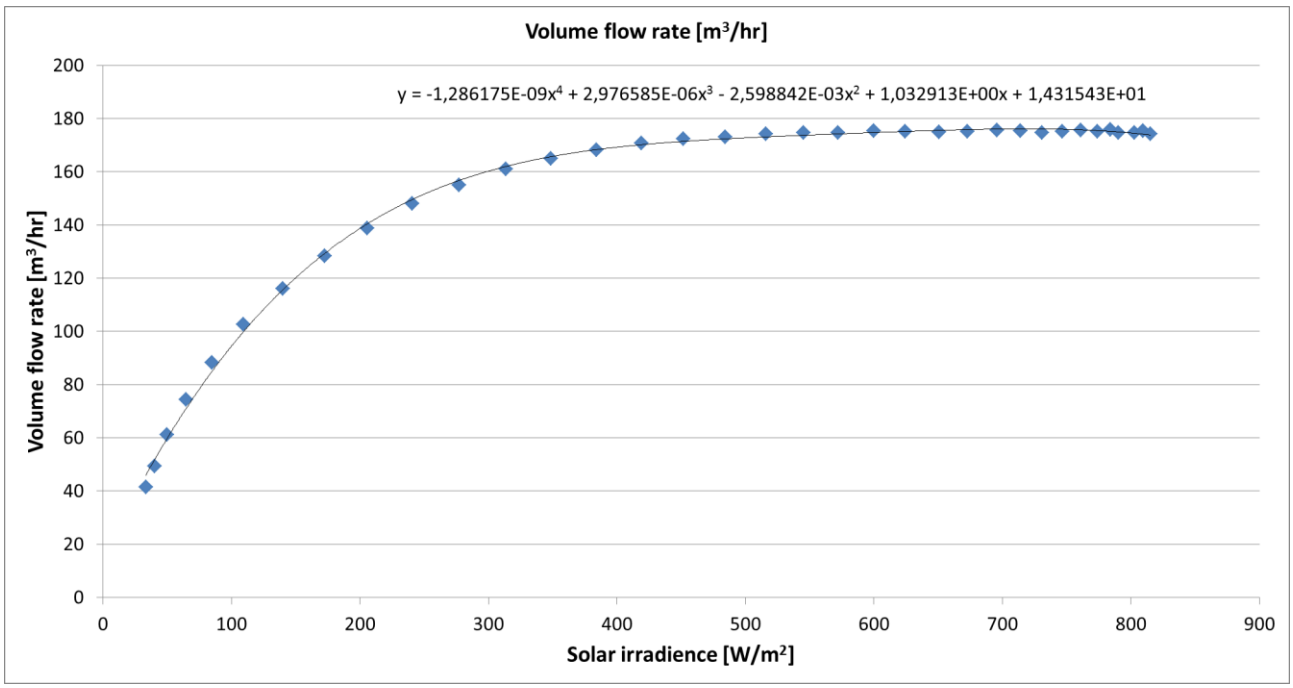

Figure 3 - Volume flow rate

For simulation purposes, the air volume flow rate through the solar air heater was assumed to have a constant increase 175 m^3/hr for values outside the maximum measured irradiance range as this was found to be the flow rate stagnation point.

Heating
The temperature rise was found as indicated in Figure 4.

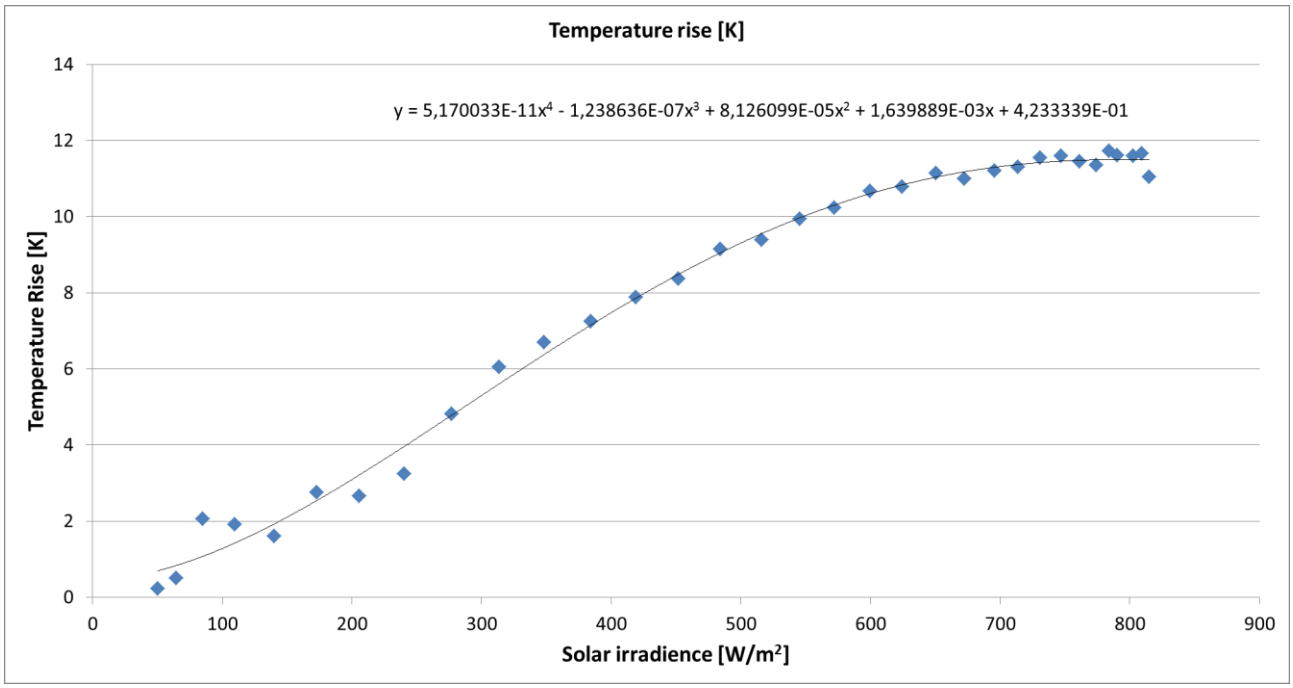

Figure 4 - Temperature rise

With a known correlation of the volume flow rate and temperature rise, the heating supplement in the heating season (Oct. 15 – Apr. 15) was calculated using the Excel workbook (described in Appendix 5 - In-house data processing):

Heating

Energy output (Oct.15 – Apr. 15)	230 kWh

Dehumidification and Ventilation

Avg. ventilation with air heater (Oct.15 – Apr. 15)	25.6 m³/hr
Avg. ventilation without solar air heater Oct.15 – Apr. 15)	7.0 m³/hr

Dehumidification and Ventilation
The moisture load of the summer house has been simulated by using the building simulation software BSim. The following graphs in Figure 5 show the relative humidity and moisture load in the house material, respectively. The data have been presented as a function of the months. Based on the simulation, the graphs show that the relative humidity and moisture content of the house materials are lowered with the solar air heater: This effect is most significant during the winter and spring periods.

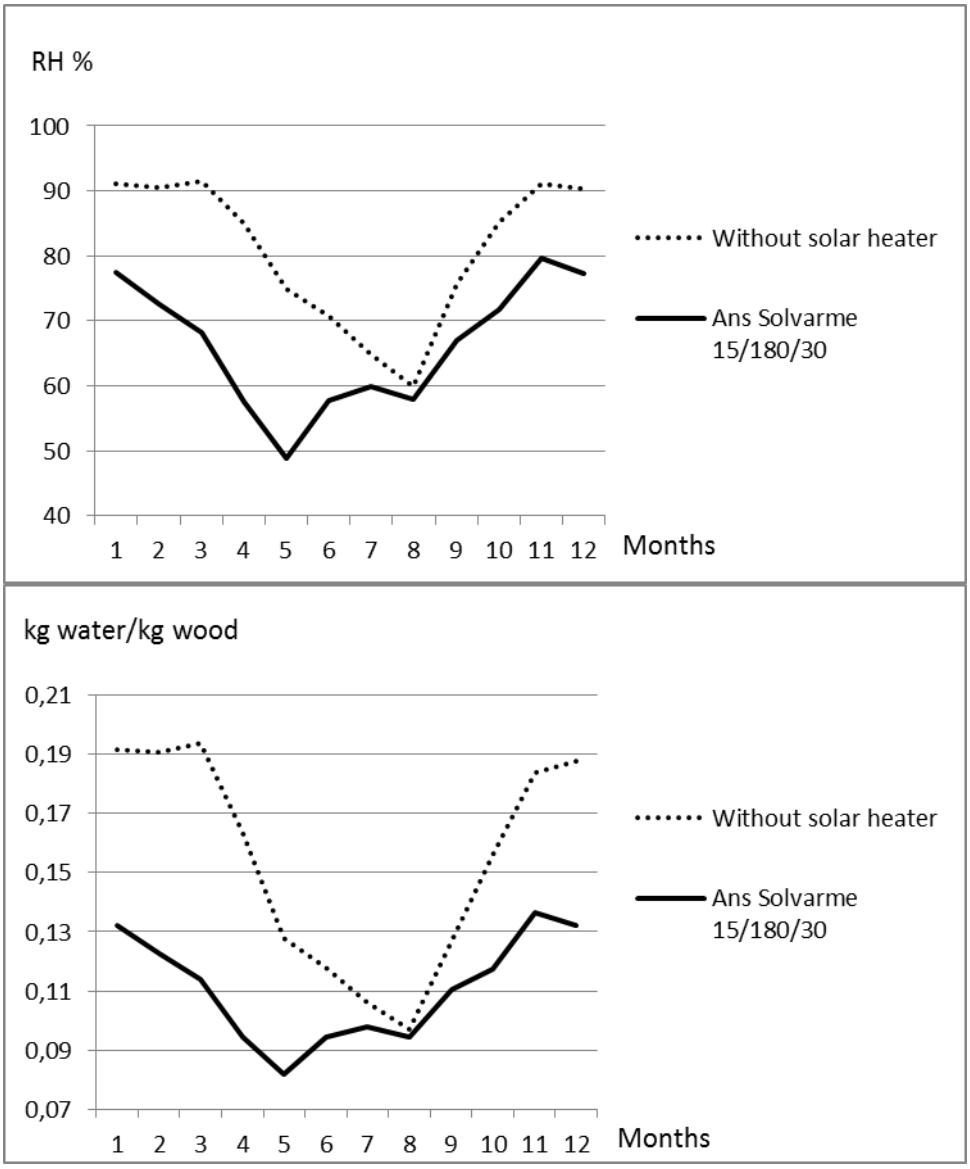

Figure 5 - Simulation results

Conclusion

It is concluded that the panel increases the average annual ventilation and provides extra heating of the house. This combined lowers the relative humidity of the air in the house and results in lower water content in the wooden material in the house.

The high relative humidity observed during wintertime > 80 % and the high water content in the wooden material of the house >18 % increase the risk of mold growth /4-5/. Based on the calculated values, the unventilated house has an average to high risk of mold growth. The installation of the solar heater lowers the water content of the wooden materials to values lower than 15 % (0.15 kg/kg). This reduces the risk of mold growth. Based on the classification in /4/, the risk of mold is now to be considered a minor risk. This leads to the conclusion that the solar panel improves the indoor climate of the specific model house.

It is important to acknowledge that this is an overall consideration and that the risk of mold growth to a great extent depends on the specific construction, e.g. local thermal bridges may lead to high condensation which may increase the risk locally. It is also important to acknowledge that the model house has to be considered as a humid house with a high moisture load. The solar panel has the potential to lower the humidity, but whether the moisture is lowered enough to give a significant indoor climate improvement may differ in a particular house. However, the present model house is dimensioned to represent an average summer house with respect to Danish building habits but with moisture problems.

8.1.1. Control Data

The procedure of data processing is repeated independently, once by the test subbody and once by the internal reviewer. This provides three independent results which are assembled into one final result.

8.1.2. Audits

No audits were performed.

8.1.3. Deviations

There were no deviations from the test plan

8.1.4. Occupational Health and Environment

The use of this product does not imply special health, safety or waste issues.

Recommendations for Verification Statement

It is recommended that a verification statement for the Ans Solvarme Vacpipe Open End 15/180/30 is issued stating that the product is functioning as claimed.

Hence, the following liability exclusions should be included in the verifications statement.

9. Liability Exclusion

ETV verifications are based on an evaluation of technology performance under specific, predetermined operational conditions and parameters as well as the appropriate quality assurance procedures. Danish Technological Institute makes no expressed or implied warranties as to the performance of the technology and does not certify that the technology always will operate as verified. The end user is solely responsible for complying with any applicable regulatory requirements.

10. Quality Assurance

The test protocol, test plan, and test report as well as the verification report were reviewed by internal and external experts according to the Quality plan for the verification, see table 2.

Table 2 - QA plan for the verification

Reviewers	**DTI**	**Experts**
Plan document with application definition, verification protocol and test plan	EMJA	SF
Report document with test report and verification report	EMJA	SF

Reviews were done by using the review report template of Danish Technological Institute.

Appendix 1 Terms and Definitions used in the Verification Protocol

Terms and definitions used in the protocol are explained in table 1:

Table 1 - Terms and definitions used by the DANETV test centers

Word	**DANETV**	**Comments on the DANETV approach**
Analytical laboratory	Independent analytical laboratory used to analyze test samples	The test center may use an analytical laboratory as subcontractor
Application	The use of a product specified with respect to matrix, target, effect and limitations	The application must be defined with a precision that allows the user of a product verification to judge whether his needs are comparable to the verification conditions
DANETV	Danish center for verification of environmental technologies	None
(DANETV) test center	Preliminary name for the verification bodies in DANETV with a verification and a test subbody	Name will be changed, when the final nomenclature in the EU ETV has been set.
Effect	The way the target is affected	The effect could be reduced energy consumption, better cooling performance etc.
(Environmental) product	Ready to market or prototype stage product, process, system or service based on an environmental technology	The product is the item produced and sold, i.e. the item that a vendor submit for verification
Environmental technology	The practical application of knowledge in the environmental area	The term technology covers a variety of products, processes, systems and services.
Evaluation	Evaluation of test data for a technology product for performance and data quality	None
Experts	Independent persons qualified for the technology in the verification	These experts may be technical experts, QA experts for other ETV systems or regulatory experts
Matrix	The type of material that the	Matrices could be cooling systems, cabinets, heat

Word	DANETV	Comments on the DANETV approach
	product is intended for	exchangers, etc.
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis	An in-house method may be used in the absence of a standard, if prepared in compliance with the format and contents required for standards.
Performance claim	The effects foreseen by the vendor on the target(s) in the matrix of intended use	None
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product	The performance parameters must be established considering the application(s) of the product, the requirements of society (regulations), customers (needs) and vendor claims
Procedure	Detailed description of the use of a standard or a method within one body	The procedure specifies the implementation of a standard or a method in terms of e.g.: equipment used
Producer	The party producing the product	None
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis	None
Target	The property that is affected by the product	Targets could be temperature [° C], energy [kWh], etc.
Test center, test subbody	Subbody of the test center that plans and performs tests	None
Test center, verification subbody	Subbody of the test center that plans and performs the verification	None
Test/testing	Determination of the performance of a product for	None

Word	DANETV	Comments on the DANETV approach
	parameters defined for the application	
Vendor	The party delivering the product to the customer	Can be the producer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance	None

Appendix 2 References

(verification protocols, requirement documents, standards, methods)

1. DANETV. Center Quality Manual, 2008

2. EN 12975-2:2006 Thermal solar systems and components - Solar collectors - Part 2: Test methods

3. DTU (2007): Effektivitet af luft/væskesolfanger, ISSN 1601-8605

4. By og Byg Anvisning 204 – Undersøgelse og vurdering af fugt og skimmelsvampe i bygninger (Investigation and Assessment of Humidity and Mold in Buildings)

5. SBi anvisning 224 – Fugt i bygning (Humidity in Buildings)

Appendix 3 Application and Performance Parameter Definitions

This appendix defines the application and the relevant performance parameters application as input for the verification and test of an environmental technology according to the DANETV method.

A3.1 Applications

A3.1.1 *The matrix is the type of material which the product is intended for.*

- Residential houses up to 70 m^2

A3.1.2 Target(s)

A target is defined as the property affected by the product

The target of the product is:

- Supplementary heating and ventilation

A3.1.3 Effects

The effect of this application is primarily:

- Improved indoor climate in unheated humid buildings

Appendix 7 Test Data Report

The effect verified in this process was reduced heating expenses and improved indoor climate in a summer house. This was verified using a simulation algorithm consisting of a design reference year (DRY data) from Copenhagen, Denmark, and building related parameters, see Appendix 5 for a detailed description of the model and input.

Operational Data
Operation of the solar air heater and data logging system was checked daily during the test. No malfunctioning of the solar air heater was detected in any part of the test.

Test 1: Assessment of the User Manual
Results from Test 1: Assessment of the user manual show that all major requirements are met.

Test 2: Solar Air Heater Performance Test
Results from Test 2: Solar air heater performance test was used as input for the calculation of simulated ventilation, heating, and dehumiditation during the heating season (Oct. 15 – Apr. 15) in a Danish design reference year (Copenhagen).

10.1. Test Measurement Summary

Test 1: Assessment of the User Manual

Intended use	
Product installation	OK
Product operation	OK
Function test	OK
Prevention of accidents	OK
Service and maintenance	OK

Test 2: Solar Air Heater Performance Test

Ventilation
The test proved that the Ans Solvarme Vacpipe Open End 15/180/30 starts ventilating at an irradiance of 33 W/m^2 and it has a correlation as shown in Figure 3.

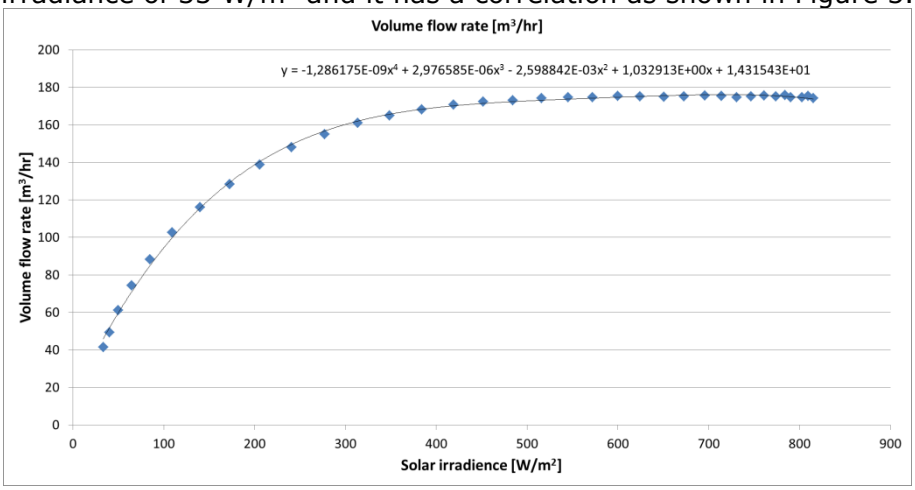

Figure 1- Volume flow rate

For simulation purposes, the air volume flow rate through the solar air heater was assumed to have a constant increase 175 m^3/hr for values outside the maximum measured irradiance range as this was found to be the flow rate stagnation point.

Heating
The temperature rise was found as indicated in Figure .

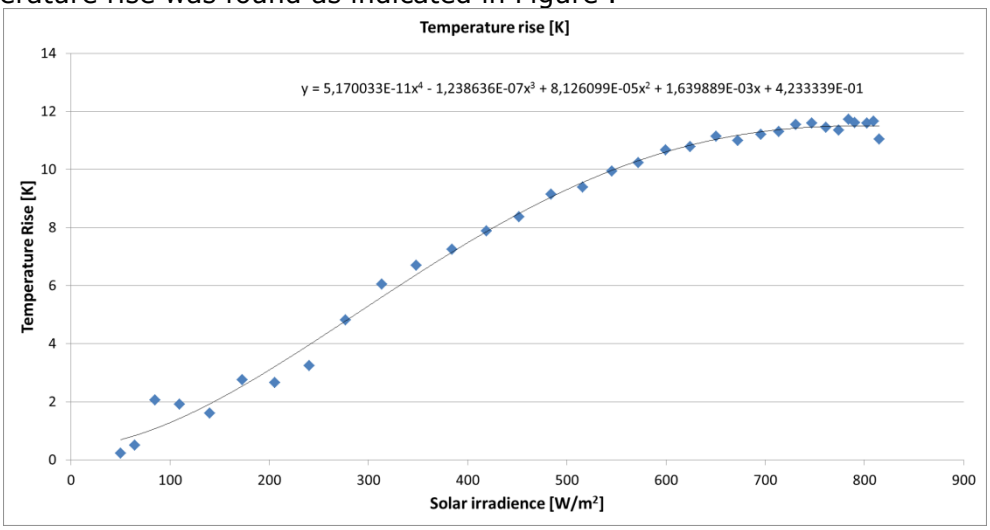

Figure 2 - Temperature rise

With a known correlation of the volume flow rate and temperature rise, the heating supplement in the heating season (Oct. 15 – Apr. 15) was calculated using the Excel workbook (described in Appendix 5 - In-House Data Processing):

Energy output (Oct.15 – Apr. 15)	230 kWh

Dehumidification and Ventilation
Using the Excel workbook (described in Appendix 5 - In-House Data Processing), the following averages were found (Oct. 15 – Apr. 15):

Avg. ventilation with solar panel (Oct.15 – Apr. 15)	25.6 m^3/hr
Avg. ventilation without solar air heater Oct.15 – Apr. 15)	7.0 m^3/hr

The humidity of the air as a function of the months (figure 3, upper) is shown for a humid summer house with and without solar heater. The lower part of the figure (3) shows the total moisture content of the house building material as mass of water pr. mass material, again the water content is shown as a function of months.

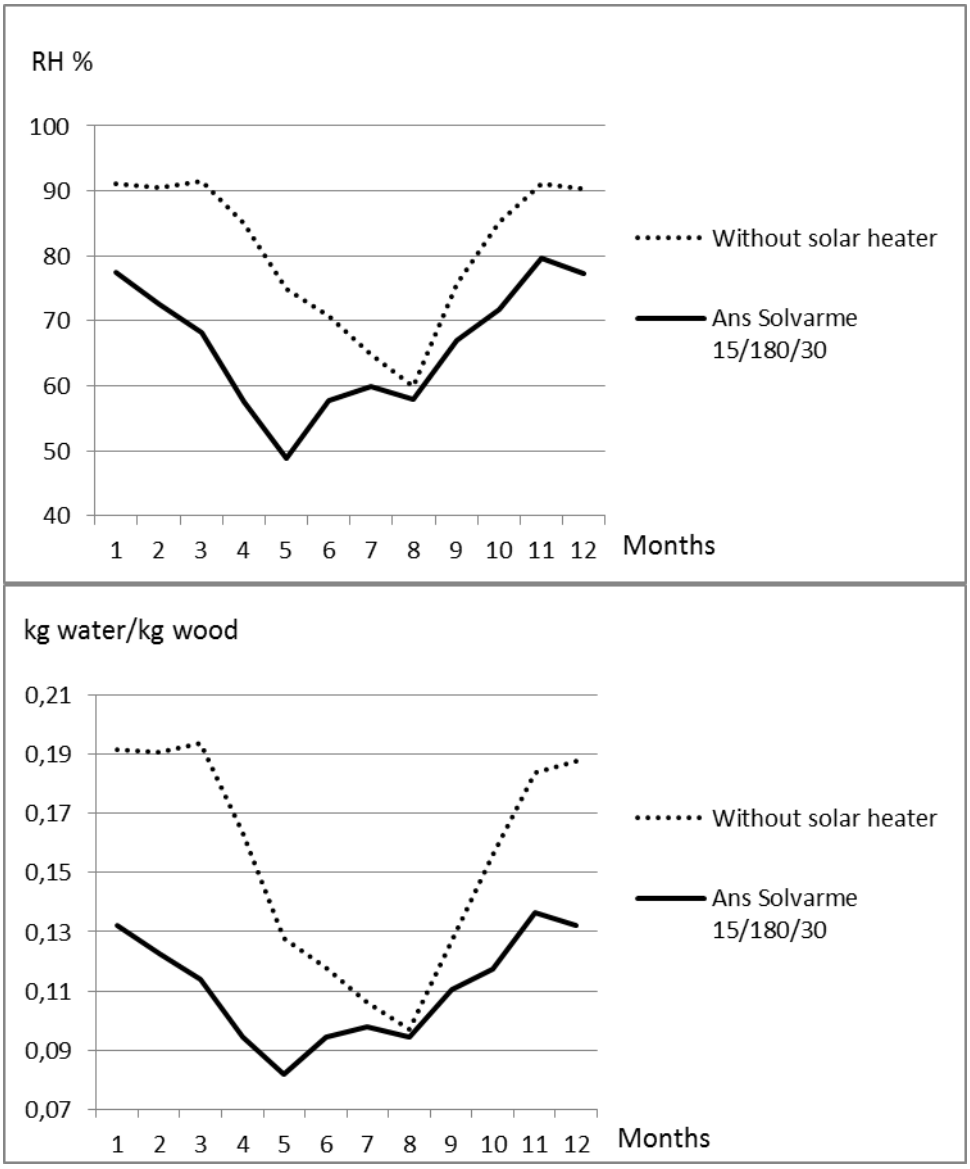

Figure 3 - Simulation results

10.2. Test Quality Assurance

The quality was assured according to the Centre Quality Manual and the procedures described in Appendix 4 – In-House Test Methods and Appendix 5 – In-House Data Processing.

10.3. Deviations from Test Plan

There were no deviations from the test plan

Comments on Data

The following points considering the effect of this product in real life applications are important to notice:

- The calculated results relating to ventilation, heating, and dehumiditation in the heating season, Oct. 15 – Apr. 15, are based on a simulation representing the average for summer houses with moisture problems in Denmark

- The design reference year used in the simulation represent climate data from a year based on statistical information. The functional effect of the solar air heater will vary from year to year in a real setting.