ETV Verification Statement

Technology Type	Superheated steam drying	
Application	Dry weight of manure fibres by steam drying	
Technology Name	SHSD - Super Heated Steam Drier	
Company	Cimbria Manufacturing A/S	
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Verification and tests of overheated steam drying was conducted and performed by FORCE Technology as DANETV Verification Centre at Fangel Bioenergi (Bigadan), Østermarksvej 70, 5260 Odense S, Denmark on behalf of Cimbria Manufacturing A/S.

DANETV was established by four independent Danish research and technology organizations and supported by the Danish Agency for Science, Technology and Innovation under the Danish Ministry of Science, Technology and Innovation to provide environmental technology verification for vendors of air emission and energy efficient technologies. Information and DANETV documents are available at WWW.etv-danamark.com.

The verification centre evaluates the performance of steam drier technologies used primarily to dry biomass. This verification statement summarizes the test results for Cimbria Manufacturing A/S, SHSD - Super Heated Steam Drier.

Verification and test description

All tests were performed in accordance with the Verification Center Verification Protocol, November 2009. The protocol introduces the technology to be verified. Based on the application and performance parameters identification the requirements for the test design has been set. The test design includes measurement methods and scope.

In order to determine the steam driers capability to dry manure fibres, measurements of the dry matter content in the manure fibres and the related energy parameters are carried out. The standardized methods to determine the moisture content in the manure fibres are CEN 14774–1 and CEN 14774–3.The protocol also includes requirements for quality management, quality assurance.

Verified technology description

The set-up for the verification test consists of the Cimbria Manufacturing A/S Super Heated Steam Drier - SHSD - and hot exhaust from a biogas engine producing district heating and electricity.

The dewatering process takes place in an enclosed cabinet without any emissions to the surrounding area.

The process is a continuous evaporation process, using overheated steam as a mean to evaporate the water from the fibrous material. The temperature of the manure is increased under pressure (1 bar abs) to above 100°C, where the water content in the media is evaporated. The evaporated water, now as steam, is withdrawn from the cabinet and condensed. The energy in the condensate is recovered and reused as district heating.

The wet manure is introduced to the SHSD through a preheated screw conveyer, which equally distributes the material on a slat conveyor belt and leads it horizontally through four sections of dryers. Finally the fibrous material leaves the cabinet in dry form for storage or further treatments.

Inside the cabinet, diagonally with the slat conveyor belt is a number of fans and heating coils. The fan in each section generates a closed circulated flow (fan – heating coil – manure material – fan etc.).

The heating coil is fed with energy from an external source.

The dewatering process accelerates when the temperature inside the cabinet increases to above 100 °C. The circulated media inside the cabinet is water vapour. Each time the water vapour passes the heating coil the temperature will increase up to the set-point – operation value. The overheated steam passes through the fibrous material and will generate an evaporation equal to the heated value of the circulated water vapour (overheated steam).

The generated overheated steam is continuous diverted from the cabinet and is reused as district heating.

The following figure 1 shows the Super Heated Steam Drier and an illustration of the energy & manure flow, respectively.

Figure 1.Super Heated Steam Drier - SHSD.

Verification of performance

Verification testing of Cimbria Manufacturing Super Heated Steam Drier – SHSD – was performed from the 28th of September to the 1st of October 2009, at Fangel Bioenergi (Biagadan), Østermarksvej 70, 5260 Odense S on behalf of Cimbria Manufacturing A/S. The test design is listed in Table 1. The test results are summarized in Table 2 to 4.

Table 1. Test design.

Performance parameters	Scope of measurement	Measurements methods and readings
Energy supply Flue gas	Volume Temperature Humidity O_2	Manuel measurement in accordance with DANAK accreditation no. 51 held by FORCE Technology /7/
Condensate	Quantity Temperature	Quantity: Manuel measurements, measured by weight and volume. Temperature: In Accordance with DANAK accreditation no. 51 held by FORCE Technology
Fibrous material inlet & outlet	Quantity Dry matter content Temperature	Quantity: Manual measurements, measured by weight. Temperature: Manuel measurement in accordance with DANAK accreditation no. 51 held by FORCE Technology Dry matter contents: Laboratory analysis in accordance with CEN/TS 14774-3 and CEN/TS 14774-1
Power Consumption	Quantity	Scanning and reading the data from the operation panel.

Dry matter content in manure fibres

In table 2 the dry matter content in the manure fibres is shown. Additional the production capacity of the SHSD drier is given. All values are average values from the entire sampling period starting on September 28th and ending on October 1st 2009.

Table 2. Dry matter content in manure fibres (28.9 – 1.10. 2009)[1].

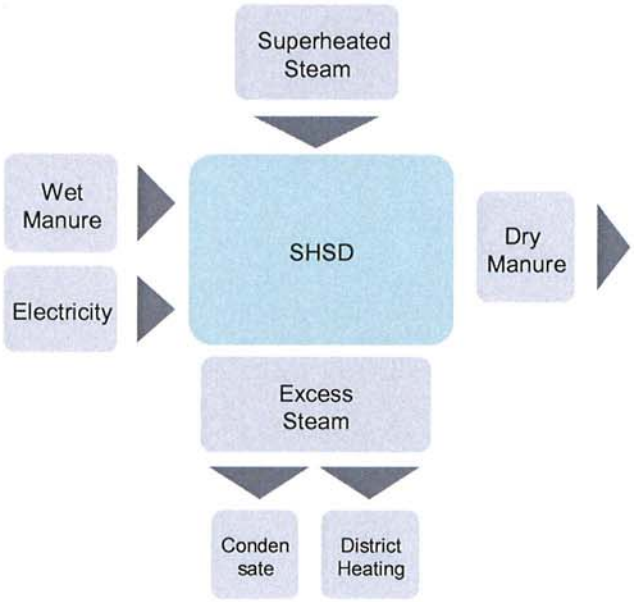
Dry matter content in manure fibres (% ± RSD[2])	
Inlet	**Outlet**
32,4 ±3,1	**90,2 ± 6,9**
Wet manure production capacity	**858 kg/h**

[1] *Refers to Test Report*
[2] *Relative standard deviation in %*

Energy Balance

The drying process of the manure is based on supply of energy in the form of heat. The sources of this energy are the flue gas from the biogas engine and the electricity to the fans circulating the drying steam inside the SHSD (see figure 1a). The energy from the flue gas is captured in the heat exchanger which overheats the steam inside the SHSD and the circulating fans ensure that superheated steam evaporates the water in the wet manure. The excess steam energy (Q_s) from the drying process is later utilized into district heating. The remaining energy after the district heating is derived as condensate. Figures 2 to 4 are schematic diagrams of the flow of energy and manure to and from the SHSD.

Figure 2. SHSD flow d**iagram of Energy and Manure.**



The energy used to dry the manure is provided by the sources mentioned above, i.e. flue gas (Q_{FG}) and electricity (Pe) assuming that the manure does not contribute to the energy input (or output). Regarding the energy provided by the fans it is assumed, that 85 % of the electricity input to the fans is used to move the fans or used to equipment outside the SHSD and the remaining 15 % is transferred to heat inside the SHSD.

The SHSD energy demand is given in table 3 and table 4 reflect the available energy from the process and how it is recovered.

Table 3. Energy demand to dry manure (28.9 – 1.10. 2009)[1]

Energy flow	Parameter		Amount MJ/h
Input	Energy contribution from the flue gas to the heat exchanger	Q_{FG}	1.407
	Electricity to fans	P_e [2]	27
		Total Input	**1.434**
Gross energy needed to evaporate 1 kg of water is 3 MJ			

[1] *Refers to the Test Report Appendix 2.*

[2] *Calculated as 15 % of electricity input to fans (27 MJ = 176,8 MJ x 15%)*

Table 4. Energy recovery in the plant (28.9 – 1.10. 2009)[1]

Energy flow	Parameter		Amount MJ/h
Output	Energy contribution from the excess steam	Q_S	1.288
	Energy loss	Q_L	146
		Total Output	**1.434**
Net energy needed to evaporate 1 kg of water is 0,6 MJ			
2,4 MJ/kg is utilized energy for district heating			

[1] *Refers to the Test Report Appendix 2.*

The calculation of energy used to dry the manure is associated with uncertainty due to the measurements included. This uncertainty is estimated to approximately 10 % and it is to some extend included in the figure of the energy loss (Q_L).

Figure 3. SHSD flow diagram including the energy loss

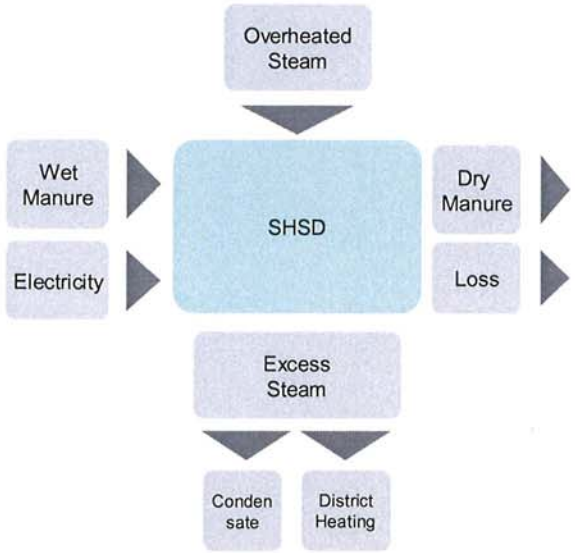
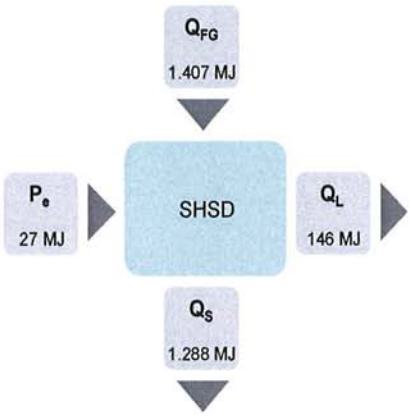


Figure 4. SHSD flow diagram with energy values (MJ)



The Air Emission and Energy Efficient Technology Verification Centre quality assurance officer has reviewed the test results and the quality control data and has concluded that the data quality objectives given in the verification protocol and test/QA plan have been attained.

This verification statement addresses the following qualities of overheated steam drying: The capability to dry manure fibres and the related energy consumption.

In accordance with the verification protocol, this verification statement is applicable to the SHSD – Super Heated Steam Drier manufactured between the signature date of the verification and 3 years hereafter.

Signed by	12/5 -10	Signed by	12/5 –10
Annemette Geertinger Technical Vice President DANETV Steering Committee member	Date	Marianne Kyed Ørbæk Project Manager DANETV Verification Centre Project Manager	Date

FORCE Technology - Air Emission and Energy Efficient Technology Verification Centre

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