WELCOME TO

Webinar on Fans
Ecodesign & optimization of Fan Systems
February 10, 2016
Webinar on Fans

Agenda

- Ecodesign regulation on Fans
  - Savings potential, scope and type definitions
  - Ecodesign requirements
  - Product information requirements on fans
  - Test method & test standards
  - Calculation examples
  - Verification procedures
  - Experience from market surveillance

- Q&A, End of webinar
Revenue 2014
DKK 1,085.1 million

Danish customers 38%

International customers 27%

Research and development activities 24%

Performance contract activities 11%
Webinar on Fans

February 10, 2016 – Online, Internet

Morten Sandholm Madsen (msma@dti.dk)
– Danish Technological Institute

- Master of Science (MSc) in Engineering (2011)
- Employments:
  - 2011- present – DTI (Energy and Indoor Environment specialist)
  - Danish Technological Institute
    - Multiple Energy Projects
    - Technical consultant for Danish Energy Agency (ECO-design fans)
    - Responsible for certified testing of fans in Denmark and is the head of the accredited laboratory facility “Vent-Lab” at Danish Technological Institute
Webinar on Fans

February 10, 2016 – Online, Internet

Erik Hvirgel Hansen (ehh@dti.dk)

– Danish Technological Institute

- Bachelor of Science (BSc) in Engineering (1976)

- Employments:
  - 1976 – 1979 – NIRAS (Design of ventilation and heating systems)
  - 1979 – 1983 – Grontmij (Design of ventilation and heating systems)
  - 1983 – present DTI (Technical test manager)
  - Danish Technological Institute
    - Multiple Energy Projects
    - Technical consultant for Danish Energy Agency (ECO-design fans and Air handling Units)
    - Responsible for certified testing of Fans and Air handling Units in Denmark and is the head of the accredited laboratory facility “AHU-Lab” at Danish Technological Institute
Introduction

- Estimated electricity consumption of fans is 344 TWh per year
- Estimated annual energy savings of 34 TWh by 2020

- First tier came into force on January 1\textsuperscript{st}, 2013
- Second tier came into force on January 1\textsuperscript{st}, 2015
Scope

- Fans designed to use with or equipped with an electrical motor with an electrical input power between 125 W and 500 kW.

- **Not in scope**
  - Products with a sole electric motor of 3 kW or less where the fan is fixed on the same shaft used for driving the main functionality
  - Products for emergency use only
  - Laundry and washer dryers ≤ 3 kW maximum electrical input power
  - Kitchen hoods < 280 W total maximum electrical input power attributable to the fan(s)
  - The ecodesign requirements do not apply to fans for specific operating conditions
Type definitions

- Axial fan

- Centrifugal fan
  - Forward curved fan
  - Backward curved fan without housing
  - Backward curved fan with housing

- Mixed flow fan

- Cross flow fan
## Ecodesign requirements 2013

<table>
<thead>
<tr>
<th>Fan types</th>
<th>Measurement category (A-D)</th>
<th>Efficiency category (static or total)</th>
<th>Power range ( P ) in kW</th>
<th>Target energy efficiency</th>
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## Ecodesign requirements

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Ecodesign requirements
Product information requirements on fans

- Required information

- (1) overall efficiency ($\eta$), rounded to 1 decimal place;
- (2) measurement category used to determine the energy efficiency (A-D);
- (3) efficiency category (static or total);
- (4) efficiency grade at optimum energy efficiency point;
- (5) whether the calculation of fan efficiency assumed use of a VSD and if so, whether the VSD is integrated within the fan or the VSD must be installed with the fan;
- (6) year of manufacture;
- (7) manufacturer’s name or trade mark, commercial registration number and place of manufacturer;
- (8) product’s model number;
- (9) the rated motor power input(s) (kW), flow rate(s) and pressure(s) at optimum energy efficiency;
- (10) rotations per minute at the optimum energy efficiency point;
- (11) the ‘specific ratio’;
- (12) information relevant for facilitating disassembly, recycling or disposal at end-of-life;
- (13) information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan;
- (14) description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan.
Product information requirements on fans

- Required information

- (1) overall efficiency ($\eta$), rounded to 1 decimal place;
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- (13) information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan;
- (14) description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan.

- A Variable speed drive must be installed with this fan
- A Variable speed drive is integrated within the fan
Test method & test standards

2. Measurement method

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations must be made using a reliable, accurate and reproducible method, which takes into account the generally recognised state-of-the-art measurement methods, and whose results are deemed to be of low uncertainty, including methods set out in documents the reference numbers of which have been published for that purpose in the Official Journal of the European Union.

- Test standards used:
  - (EC) No 640/2009
  - ISO 5801:2009 – Industrial fans – Performance testing using standardized airways (The “bible” of fan testing)
Test method & test standards

Optimum energy efficiency point
(b) where the fan includes a variable speed drive, calculate the overall efficiency using the following equation:

$$\eta_e = \left( \frac{P_{u(s)}}{P_{ed}} \right) \cdot C_c$$

where:

$\eta_e$ is the overall efficiency;

$P_{u(s)}$ is the fan gas power, determined according to point 3.3, of the fan when it is operating at its optimal energy efficiency point;

$P_{ed}$ is the power measured at the mains input terminals to the variable speed drive of the fan when the fan is operating at its optimal energy efficiency point;

$C_c$ is a part load compensation factor as follows:

— for a motor with a variable speed drive and $P_{ed} \geq 5$ kW, then $C_c = 1.04$,

— for a motor with a variable speed drive and $P_{ed} < 5$ kW, then $C_c = -0.03 \ln(P_{ed}) + 1.088$. 
(b) where the fan includes a variable speed drive, calculate the overall efficiency using the following equation:

$$\eta_e = \left( \frac{P_{u(s)}}{P_{eq}} \right) \cdot C_c$$

where:

- $\eta_e$ is the overall efficiency;
- $P_{u(s)}$ is the fan gas power, determined according to point 3.3, of the fan when it is operating at its optimal energy efficiency point;
- $P_{eq}$ is the power of the fan operating at its energy efficiency point;
- $C_c$ is a part load factor — for a motor.

**Compliance result:** PASSED

**Average test result:**

<table>
<thead>
<tr>
<th>Measured efficiency:</th>
<th>Efficiency grade (N):</th>
<th>Target energy efficiency ($n_{target}$):</th>
<th>Requirement for compliance ($n_{target} \cdot 0.9$):</th>
</tr>
</thead>
<tbody>
<tr>
<td>77.5%</td>
<td>61</td>
<td>45.6%</td>
<td>41%</td>
</tr>
</tbody>
</table>
Test method & test standards

- Setup definitions

(2) ‘Measurement category A’ means an arrangement where the fan is measured with free inlet and outlet conditions.

(3) ‘Measurement category B’ means an arrangement where the fan is measured with free inlet and with a duct fitted to its outlet.

(4) ‘Measurement category C’ means an arrangement where the fan is measured with a duct fitted to its inlet and with free outlet conditions.

(5) ‘Measurement category D’ means an arrangement where the fan is measured with a duct fitted to its inlet and outlet.
Test method & test standards

- Measurement category A

a.) Flowrate determination using Venturi nozzle on end of chamber
Test method & test standards

- Measurement category B
Test method & test standards

- Measurement category C
Test method & test standards

- Measurement category D
Test method & test standards

- Calculation differences
  - Efficiency before:
    \[ \frac{q_v \cdot p}{P_e} \]
  - Efficiency now:
    \[ \frac{q_v \cdot k_{ps} \cdot p}{P_e} \]

- Theoretical difficult calculation
  - Mach-factor og number
  - Stagnation pressure

Hydraulic power
Input power
Compressibility coefficient

Theoretical diffcalculation

\[ k_{ps} := \frac{Z_k \cdot \log(r)}{\log[1 + Z_k \cdot (r - 1)]} \]

\[ Z_k := \frac{1.4 - 1}{1.4} \cdot \frac{\rho_{sg} \cdot P_r}{q_m \cdot p_F} \]
Calculation example

- Low pressure fan
  - Pressure loss: 150 Pa
  - Flow rate: 11,000 m$^3$/h

Example 1

Bar chart 1 – shows the static fan efficiency calculated in 5 different ways.
Calculation example

- Intermediate pressure fan
  - Pressure loss: 570 Pa
  - Flow rate: 11,000 m$^3$/h

**Example 2**

Bar chart 2 – shows the static fan efficiency calculated in 5 different ways.
Calculation example

- High pressure fan
  - Pressure loss: 1.800 Pa
  - Flow rate: 11.000 m³/h

Example 3

Bar chart 2 – shows the static fan efficiency calculated in 5 different ways.
Verification procedure

3. If the result referred to in point 2 is not achieved:

— for models that are produced in lower quantities than five per year, the model shall be considered not to comply with this Regulation,

— for models that are produced in quantities of five or more per year, the market surveillance authority shall randomly test three additional units.

4. The model shall be considered to comply with the provisions set out in this Regulation if the average of the overall efficiency ($\eta_e$) of the three units referred to in point 3 is at least target energy efficiency $\times 0.9$ using the formulas in Annex II (Section 3) and the applicable efficiency grades from Annex I.

5. If the results referred to in point 4 are not achieved, the model shall be considered not to comply with this Regulation.
## Market surveillance

<table>
<thead>
<tr>
<th>Test no.</th>
<th>Measurement category</th>
<th>Specified performance [%]</th>
<th>Measured performance [%]</th>
<th>Requirements [%]</th>
<th>Input power [W]</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent 01</td>
<td>A</td>
<td>-</td>
<td>43,7</td>
<td>26,9</td>
<td>1.125</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 02</td>
<td>D</td>
<td>78,8</td>
<td>49,2</td>
<td>47,7</td>
<td>1.730</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 03</td>
<td>D</td>
<td>69</td>
<td>77,5</td>
<td>41</td>
<td>346</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 04</td>
<td>D</td>
<td>53,2</td>
<td>56,3</td>
<td>45,3</td>
<td>958</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 05</td>
<td>D</td>
<td>51,8</td>
<td>47,2</td>
<td>41,4</td>
<td>370</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 06</td>
<td>C</td>
<td>-</td>
<td>22,8</td>
<td>32,3</td>
<td>79</td>
<td>Failed</td>
</tr>
<tr>
<td>Vent 07</td>
<td>D</td>
<td>64,5</td>
<td>69,1</td>
<td>54,5</td>
<td>4.619</td>
<td>Passed</td>
</tr>
<tr>
<td>Vent 08</td>
<td>A</td>
<td>37,5</td>
<td>32,4</td>
<td>33,7</td>
<td>1.216</td>
<td>Failed</td>
</tr>
<tr>
<td>Vent 09</td>
<td>A</td>
<td>-</td>
<td>17,2</td>
<td>24,7</td>
<td>444</td>
<td>Failed</td>
</tr>
</tbody>
</table>
Market surveillance

- Leakages
- Missing transitions
- Transitions differs from EN 5801
Market surveillance

- Leakages
- Missing transitions
- Transitions differs from EN 5801

Figure 31 — Transition

\[ L \geq 3 \sqrt{\frac{4b_2h_2}{\pi}} \]
Market surveillance

- Practical information

- Measurement category A – no transitions
- Measurement category B – transition from outlet
- Measurement category C – transition from inlet
- Measurement category D – transitions from both in and outlet

If the inlet or/and the outlet are circular and have standard dimensions there is no need for transitions. Transitions shall be formed according to EN 5801

In the Nordic countries round duct sizes is used:

- 63, 80, 100, 125, 160, 200, 250, 315, 400, 500 og 630
Webinar on Fans

Thank you for listening

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  Danish Technological Institute: http://dti.dk