Position paper on the Draft Ecodesign Regulation (Review of EU 327/2011) regarding **High pressure/Low volume fans**

The draft eco-design regulation on fans has an impact on a wide range of fan applications – not only on building ventilation but also on various industrial processes requiring e.g. dust conveying fans or high pressure/low volume (HPLV) fans. The discussions during the latest stakeholder meeting showed that those industrial aspects haven't been considered to a sufficient scale in the review study. The proposed efficiency requirements 2020 to be applied to HPLV fans can't be met. This document describes the problem and contains a proposition to solve it.

Industrial sectors and applications concerned

Applications requiring high pressures at low flow rates (e.g. 7000 Pa at 1000m³/h) can be found in many different industries, e.g. cement industry, glass bottle manufacture, food industry, etc. Here HPLV fans serve very specific production processes, for example mould cooling, forced draft process air, dust collection, combustion air, fume extraction, indirect transportation, sealing air, etc. (see examples further down).

Several fan manufacturers in Europe, mainly SMEs, have put their main focus on the mentioned industrial sectors. In Germany there are more than six well-known companies (DLK, Piller, Pollrich, Reitz, Rotamill, Ventapp, etc.) with combined more than 1300 employees and a sales volume around 200 Mio. €. Although HPLV fans cover a wide range of various applications it is a niche market in terms of sales quantity.

Figure 1 Sealing air in redundant layout

The Issue

If the new efficiency requirements for centrifugal fans proposed in the draft revision would come into force, many of the applications mentioned above can't be put into service in the future, as the fans can't reach the new efficiency requirements (see Figure 1).

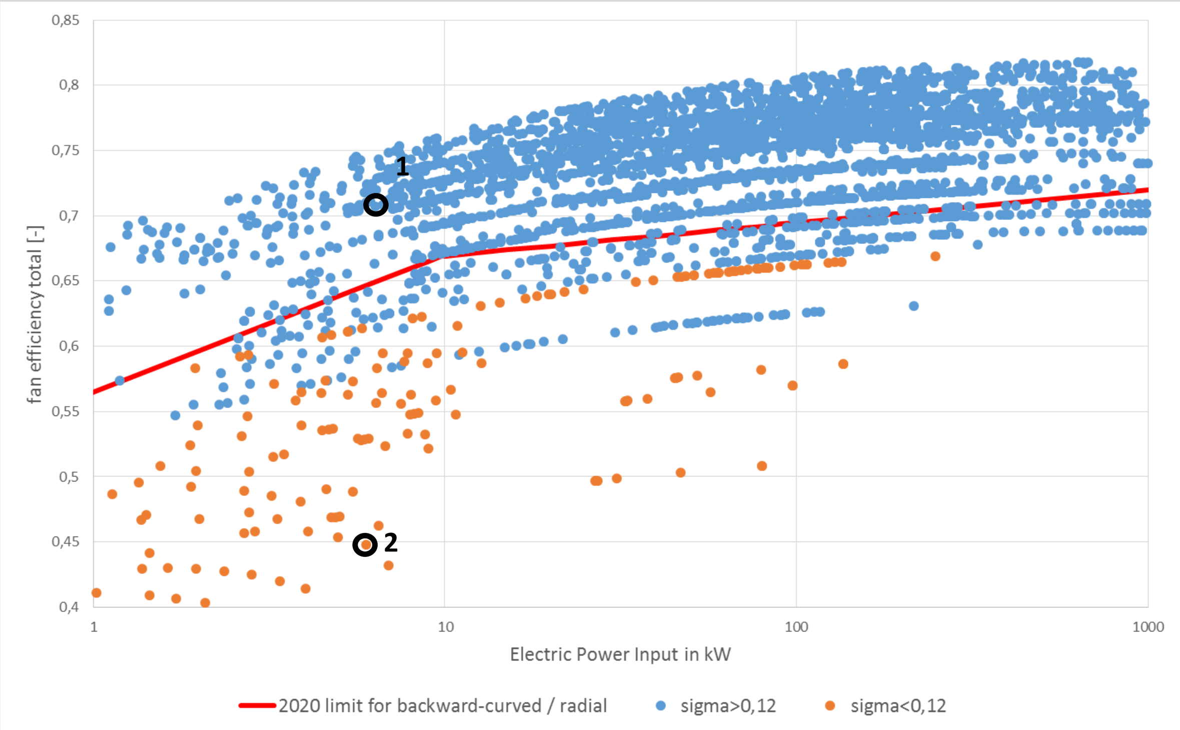

Figure 2: Total fan efficiency (measurement category B, D) in dependence of electric motor power and specific speed sigma at best efficiency point

Figure 2 contains catalogue data provided by relevant HPLV fan manufacturers. The specific speed σ_{bep} is used as parameter characterizing the ratio between volume flow rate and total pressure at best efficiency point (BEP). This characteristic number is defined as:

$$\sigma_{bep} = n * \frac{2 * \sqrt{\pi * q_{v,bep}}}{\left(2 * \frac{p_{f,bep}}{\rho}\right)^{\frac{3}{4}}}$$

n: Number of revolutions

$p_{f,bep}$: Total Fan pressure (total) at BEP

ρ: Fluid density

$q_{v,bep}$: Volume flow rate at BEP

Characteristic data of example 1 and 2:

	q_v in m^3/h	p_{tot} in Pa	P_a in kW	η_t	σ_{bep}
1	11.232	1.439	6,34	0,71	0,496

2	600	10.000	3,46	0,45	0,056

The data demonstrate the big difference of design and duty point of both examples although featuring a comparable electric power input.

Justification of the lower fan efficiency

Impellers used in centrifugal fans for HPLV applications always have to feature a small ratio between inlet and outlet diameter. Additionally the distance between back plate and covering plate of the impeller has to be very small compared to its overall dimensions. Otherwise the pursued duty point can't be met. Based on these geometrical necessities the coated surface is large in comparison to the flowed cross-section area. In consequence fans for HPLV applications have much higher friction losses and thus considerable lower efficiencies.

The well-known Cordier diagram (Figure 3) shows the interrelation between specific speed, diameter number and efficiency. It indicates that fans with small σ_{bep} (<< 0,3) have generally a significant lower efficiency than centrifugal fans with σ_{bep} = 0,3...0,6.

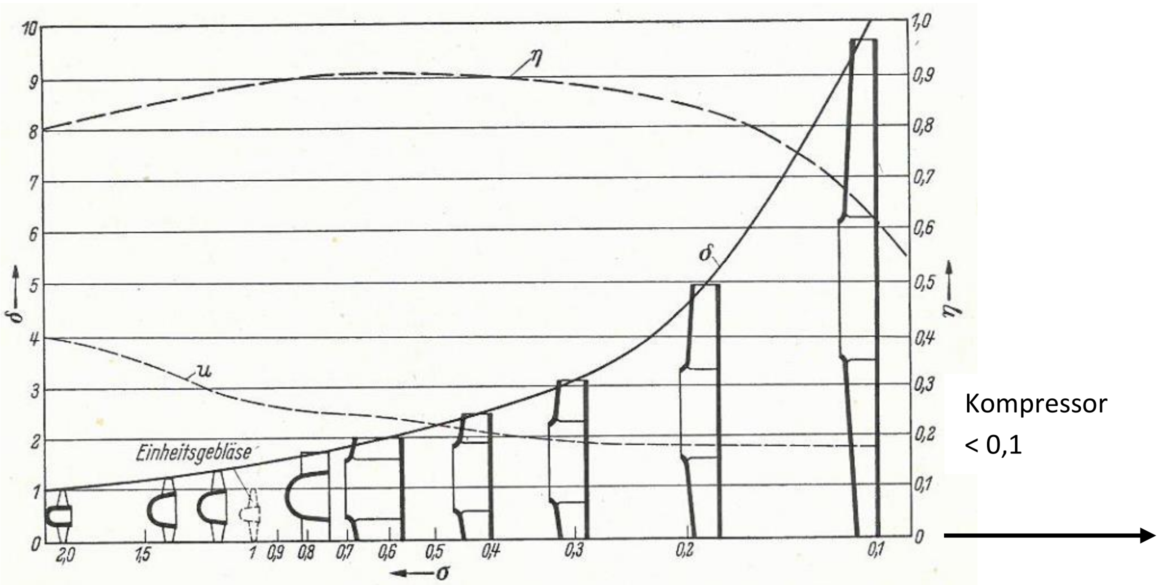

Figure 3: Cordier diagram (Eck, 2003)

HPLV fans are, independently from manufacturer, typically marked by a specific speed σ_{bep} <0,15.

Use of flow-machines with alternative designs

1. Fan with higher specific speed and higher fan efficiency at BEP → Not expedient, because
   - the fan is possibly running in stall.
   - the fan works outside of his design point and a safe operation can't be guaranteed.
   - the fan has an undefined working point, a stable operation in the application is at risk.
   - at the duty point the fan operates with an efficiency lower than that of a fan perfectly designed for the HLPV application. This leads to a higher energy consumption of the application.

2. *Compressor* with smaller specific speed (σ_{bep}<0,12) → Not expedient, because

   - the efficiency of compressors is lower even in BEP. This leads to a higher energy consumption of the application.

Conclusion: There is no design option available being technically suitable and more efficient.

Regulatory options and propositions for implementation

Based on the current state of knowledge it will not be possible to reach the minimum fan efficiency with HPLV fans. Therefore we see the following regulatory options:

<u>Option 1:</u>

Fans with specific speed σ_{bep}<0,12 (HPLV fans) remain in the scope of the fan regulation, but without fan energy efficiency requirement. Information requirements have to be met.

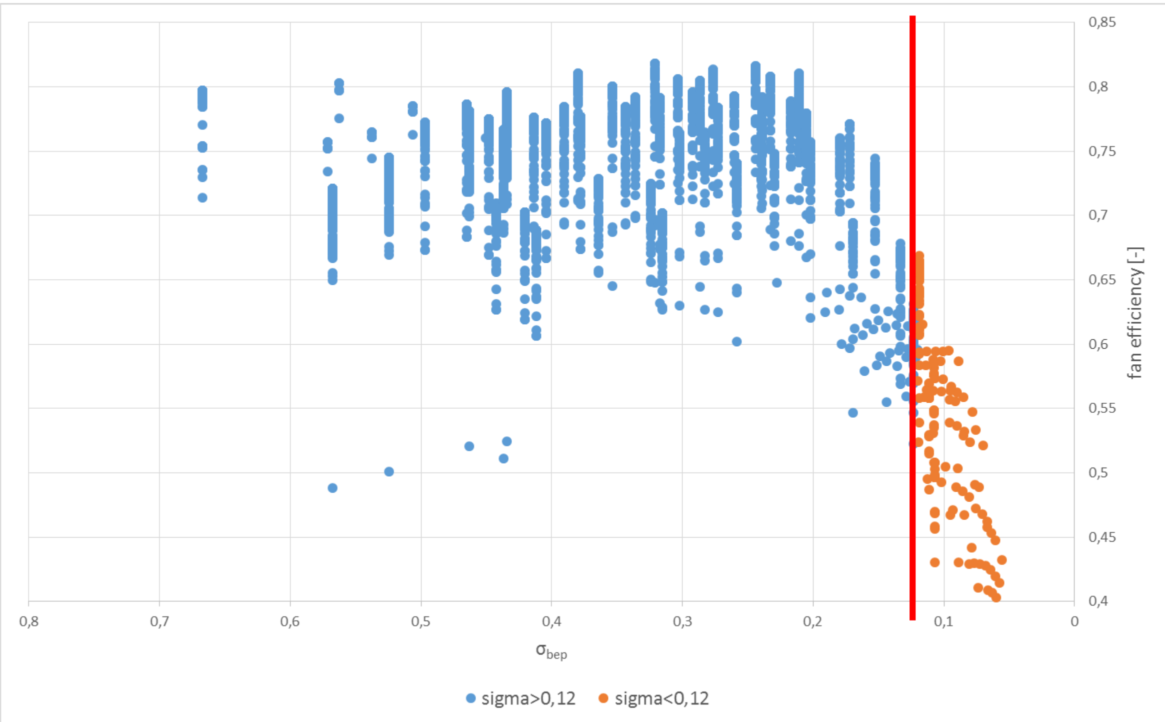

Figure 4: Total fan efficiency in dependence of specific speed at best efficiency point σ_{bep}

Justification:

- the current metric of the regulation (minimum fan efficiency related to electric power input) can be retained
- fan manufacturers can easily calculate the relevant parameter σ_{bep} and display it within the product information data sheet
- fans in HPLV applications can further on be designed to operate with optimum efficiency and thus lowest energy consumption
- the exclusion of HPLV fans doesn't create a loophole, as they can't be misused in applications requiring a high specific speed
- fan manufacturers will not find themselves constrained to somehow by-pass the legal requirements of the fan regulation
- a possible economic damage can be prevented as (new) industrial plants requiring HPLV fans won't be pushed outside of Europe

Adjustment of the draft eco-design regulation for fans based on regulatory option 1:

Article 1 Subject matter and scope

1. *This Regulation shall not apply to:*

   a) *fan-impellers mounted on the shaft of electric motors of 3 kW or less with the sole purpose of cooling the motor itself;*

   b) *fans integrated in laundry and washer dryers $\leq$ 3 kW maximum electrical input power;*

   c) *fans integrated in kitchen hoods < 280 W total maximum electrical input power attributable to the fan(s);*

   d) *fans with a best energy efficiency point (bep) at 8000 rotations per minute or more;*

   e) *fans with a specific speed σ_{bep} < 0,12 and electrical input power < 10kW at best energy efficiency point (bep), except for information requirements.*

Annex I Definitions

(21) *'Jet-fan impeller efficiency' $\eta_r(T)$ is the fan gas power output derived from the measured thrust of a jet fan divided by the mechanical power supplied to the impeller of the fan, in accordance with Annex V, point 3.*

(22) *'Density ρ' is the standard air density (1,2 kg/m³)*

(23) *'Specific speed σ_{bep} describes the ratio between flow rate and total fan pressure (total) as dimensionless characteristic number determined at bep and following the expression*

$$\sigma_{bep} = n * \frac{2 * \sqrt{\pi * q_{v,bep}}}{\left(2 * \frac{p_{f,bep}}{\rho}\right)^{\frac{3}{4}}} \quad .$$

Annex III Product information requirements

1. ...

2. The following information shall be displayed:

...

(6) year of manufacture

(new 7) specific speed σ at bep

(new 8) manufacturer's name, registered trade name or registered trade mark, and the address at which the manufacturer can be contacted

...

Option 2:

As alternative to the exclusion of HPLV fans from efficiency requirements the fan energy efficiency requirement for HPLV fans can be set depending on the specific speed σ_{bep} by means of a linear function.

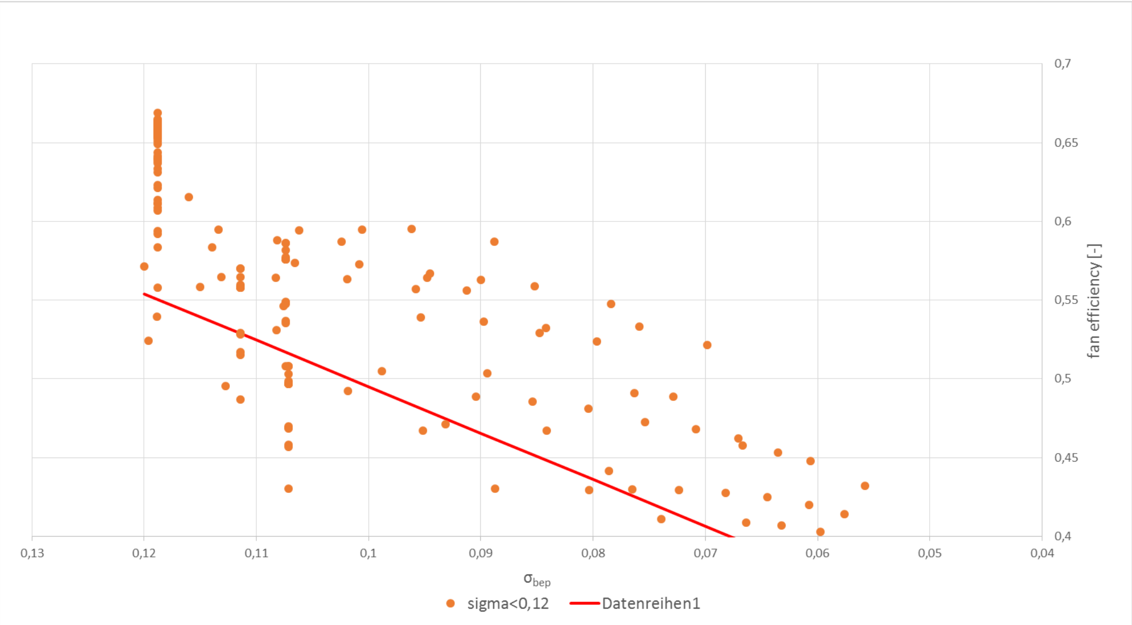

Figure 5: Total fan efficiency in dependence of specific speed at best efficiency point σ_{bep} for σ_{bep}<0,12

The limit curve (red line in figure 5) following the expression

$$\eta_{min} = 2{,}95 * \sigma_{bep} + 0{,}2$$

shall be applied for fans with $\sigma_{bep} < 0{,}12$.

Adjustment of the draft eco-design regulation for fans based on regulatory option 2:

Annex I Definitions

(24) *'Jet-fan impeller efficiency' $\eta_r(T)$ is the fan gas power output derived from the measured thrust of a jet fan divided by the mechanical power supplied to the impeller of the fan, in accordance with Annex V, point 3.*

(25) *'Density ρ' is the standard air density (1,2 kg/m³)*

(26) *'Specific speed σ_{bep} describes the ratio between flow rate and total fan pressure (total) as dimensionless characteristic number determined at bep and following the expression*

$$\sigma_{bep} = n * \frac{2 * \sqrt{\pi * q_{v,bep}}}{\left(2 * \frac{p_{f,bep}}{\rho}\right)^{\frac{3}{4}}} \quad .$$

Annex II Ecodesign requirements for fans

The minimum fan efficiency (ηmin) for fans with specific speed $\sigma_{bep} \geq 0,12$ values as a function of the electric power input Pe (in kW), efficiency grade N from the equations:

- *for fans with $P_e < 10$ kW: η_{min} = 0.0456 LN(Pe) – 0.105 + N*
- *for fans with $P_e \geq 10$ kW: η_{min} = 0.011 LN(Pe) – 0.0206 + N*

as set out in Table 1 below per fan type (axial, mixed flow, centrifugal, cross flow), efficiency category (static, total) and measurement category (A, B, C or D) as appropriate.

The calculation of the efficiency grade N for mixed flow fans involves the fan flow angle α, in degrees rounded to the nearest integer, with reference to the measurement method in Annex III.

Fan type	***Measurement category***	***Pressure***	***N***
Axial	*A, C*	*static*	*0,50*
	B, D	*total*	*0,64*
Forward curved and radial <5kW	*A, C*	*static*	*0,52*
	B, D	*total*	*0,57*
Forward curved and radial ≥5kW, Backward curved	*A, C*	*static*	*0,64*
	B, D	*total*	*0,67*
Mixed flow	*A, C*	*static*	*0,57+0,07·(α*

			−45)/25
	B, D	total	0,67
Cross flow	B, D	total	0,21

The minimum fan efficiency (η_{min}) for fans with specific speed $\sigma_{bep} < 0{,}12$ and electrical input power < 10kW values as function of σ_{bep} :

$$\eta_{min} = 2{,}95 * \sigma_{bep} + 0{,}2 \,.$$

The minimum fan efficiency is related to measurement category B or D and efficiency category (pressure) total.

Annex III Product information requirements

1. *…*
2. *The following information shall be displayed:*

…

(6) year of manufacture

(new 7) specific speed σ at bep

(new 8) manufacturer's name, registered trade name or registered trade mark, and the address at which the manufacturer can be contacted

…

Companies

Piller

PILLER develops, designs and manufactures customized blowers and compressors. Every single machine device is exclusively made to order, in accordance with the customer's requirements. Whether blowers for mechanical vapour recompression, fines removal blowers for CCR platforming, process blowers with steam heated casing or hot-gas circulators for industrial furnaces – every one of our products is a high-quality, technically sophisticated system.

Dr.-Ing. Peter Hermerath / Technical Product Manager

PollrichDLK FanFactories

The common trademark "Pollrich DLK Fan Factories" pools more than 140 years of production know-how of industrial fans by the manufacturers Pollrich Ventilatoren GmbH and DLK Ventilatoren GmbH. A workforce of more than 190 employees at the two production sites Mönchengladbach and Schöntal-Berlichingen manufacture axial and centrifugal fans for nearly any industrial requirement.

Dr.-Ing. Daniel Wolfram / Technical Director

Reitz

In 1984, Konrad Reitz foundet the Konrad Reitz Ventilatoren GmbH und Co. KG in Höxter Albaxen and has ever since been an owner-operated family enterprise. Reitz offers high-capacity radial fans for each application and industrial branch, axial fans, equipment and acoustic protection devices – all services and supplies from a single source.

Dipl.-Ing. Christian Rohdich / Technical Director

Rotamill

The globally active 40-year-old traditional enterprise ROTAMILL Anlagen-, Apparate und Ventilatorenbau GmbH (ROTAMILL), based in Siegen, North Rhine-Westphalia is a company specializing in industrial fans, air purification systems, sulfur grid plants and process plant engineering Specialist company. Production is carried out, including the construction of control in our own factory; a high in-house production ratio ensures great flexibility and high quality standards.

Total produced several hundreds of plants and thousands of fans for complex tasks and requirements of the company and delivered to well-known customers.

Dipl.-Ing. Christian Pohl / technical managing director

Helios Ventilatoren

Helios is a forward-looking family business and is one of Europe's leading fan manufacturers with over six decades of designing and manufacturing fans and components for the ventilation industry. This has resulted in enabling Helios to offer a comprehensive range of fans and ancillaries including explosion proof fans.

The range extends from mini fans for domestic ventilation to complete systems for commercial and industrial applications. Large axial fans extend the range of volumes to reach in access of two million m^3/h. These are used on applications covering cooling, heating, refrigeration, drying, etc.

Dipl.-Ing. Harry Keller / Product Manager

Witt Group

The Witt Group of companies comprising amongst other Alldays Peacock Ltd. (founded 1625), Meidinger AG (founded 1900) and Witt & Sohn AG(founded 1945) is a preeminent manufacturer of industrial fans for special applications such as metros, tunnels, ships, power plants, bio gas power generation, chemical and pharmaceutical plants. The product range encompasses both high performance axial and centrifugal fans. Approximately 15% of the turnover is earned selling high pressure (above 5000 Pa) centrifugal fans.

Karsten C. Witt/ Managing Director

Bibliography

[1] Eck, B. (2003). *Ventilatoren.* Berlin: Springer-Verlag.

[2] Pelz, P. D.-I. (2015). *Evaluation of the physical backgraund for the efficiency rise on axial and centrifugal fans.* Darmstadt: Technische Universität Darmstadt.