EU FAN REGULATION 327/2011 REVEIW STUDY / 2nd STAKEHOLDER MEETING FOLLOW UP 13th FEBRUARY 22:09 2015 DENMARK

Dear René Kemna and Roy van den Boorne,

On behalf of Multi-Wing, I am providing written comments related to the EU Fan 327/2011 Review discussion document and the second stakeholder meeting on 22 January in Brussels.

Comments structured around eight questions and answers:

1. What is the theoretical / experimental limit for axial impellers?
2. What is the relationship between compliance and different configurations linked to rpm and/or stator (orifice vs bell-mouth vs bell-mouth + diffuser)?
3. Do fan selections distinguish themselves from the best efficiency point?
4. Are stand-alone performance predictable when integrated into other products?
5. Does a defined set-up for axial impellers exist?
6. What is the challenge with truly reversible fans?
7. What is the challenge with not allowing non-ventilation manufacturers to estimate overall fan efficiency and input power?
8. What are the potential design challenges in general with tight space constraints and for oil coolers / radiators?

Multi-Wing supports policies to protect our shared environment. However, the following expresses Multi-Wings contribution to help ensure an optimal regulatory impact. This by emphasizing critical areas with recommendations linked to the EU Fan Regulation where there also is a valuable need for clear guidelines and minimum efficiency requirements. High-level summary of suggested guidelines to maximize the impact of the EU Fan Regulation:

EU FAN REGULATION REVIEW RECOMMENDATIONS FOR AXIAL IMPELLERS			
Efficiency Ratio	• Maintain current ISO 12759 Metrics (Best Efficiency) and definer higher targets for ventilation and lower for non-ventilation applications, or • Introduce Application Dependent FER Metric (Design Point) by AMCA International www.amca.org/whitepapers		
Suggested Targets for current metric and axial fans measured with free inlet and free outlet (A)			
Detailed Recommendation	**Designed for / Space availability for**	**2018**	**2020**
	Orifice installation	N40	N42
	Housing / Bell-mouth installation	N43	N44
	Housing / Bell-mouth + Diffusor installation	N44	N48
	Truly reversible fans	N40	N40
Simplified Recommendation	Ventilation	N44	N48
	Non-Ventilation	N40	N42
	Truly reversible fans	N40	N40
Alternative test (default stator) for non-fan products (Build-in)			
Detailed Recommendation	Axial impellers designed to operate without housing		Default orifice
	Axial impeller designed to operate with housing		Default bell-mouth
Simplified Recommendation	If simplification is needed for purposes of regulation		Default bell-mouth
Fan efficiency Calculation			
Ventilation	Only direct measurement shall be allowed		
Non-Ventilation	Estimation method shall be allowed		
Fan Configuration Adjustments within non-fan products			
Shall be allowed to counter system effects and range efficiency instead of peak efficiency should be considered (ErP Optimal configuration shall be able to comply)			
Oil Coolers / Radiators			
Reduced targets when installation conditions are expressed by thight space contraints (e.g. wind turbines and on-/off road machinery)			

1. What is the static efficiency limit for axial impeller fans?

Axial fans and driven axial impellers are well established for ventilation, cooling and heating applications of all kind. Axial fans may be with or without casing, bell-mouth, inlet or outlet guide-vanes and diffusers, according to both standards and handbooks. Further, axial fans may be placed with or without space restrictions.

A special type of axial fan covers only the impeller designed to operate without a casing, the impeller situated in hole in a wall or partition (Orifice). The impellers designed specifically to orifice are designed to co-operate with an orifice flow pattern. If the free flow can be substantially increased, by rounding the orifice edge or fitting the a rounded inlet ring and if the rounding is expanded into a true bell mouth and a small “casing” is formed around the impeller, the fan becomes in effect an axial fan, and is in fact better served by an airfoil impeller. This according to Woods practical guide to fan engineering and Fans and Ventilation – a practical guide by Cory.

Multi-Wings supplies both axial fan impellers designed for use with orifice and housing. Multi-Wing supplies axial airfoil impellers without casing to among other the leading axial fan manufacturers covering both wall mounted, short and long ducted solutions. However, Multi-Wing also designs axial fans optimized towards an orifice covering for example our “pressure max series” supplied to among other leading off-road machinery manufacturers.

The following covers theoretical and experimental information about the best achievable static efficiency linked to test configuration A (free inlet and free outlet). Hence, guide vanes will not be covered though incorporating these may be used to improve total efficiency. Further, the experimental information does not take into account the achievable static efficiency related to fans above 3meters in diameter.

The theoretical limit for an **impeller** in a hole in a wall or partition (Orifice) is approximate **59%**. However, maximum achievable fan efficiency is related to diameter size c.f. ISO 12759. For example, Multi-Wings test experience shows that the maximum efficiency limit in orifice is around **56%** in general and around **48%** for a 500mm impeller.

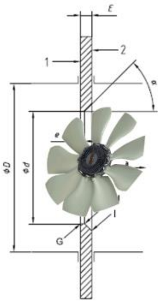
Adding a **bellmouth inlet** may add around another 1% to 12% in static efficiency dependent upon configuration. For example Multi-Wings test experience shows that the maximum static efficiency with a bell-mouth (R/D=10) and outlet covering the impeller is around **63%** in general and around **53%** for an 500mm impeller.

Adding a **diffusor** may ad around another 5% to 15% in static efficiency again dependent upon configuration. Diffusers help to convert some of the fan velocity pressure into fan static pressure, which is the only useful form at an open outlet. Hence, from Multi-Wings experience and assuming 10% in diffusor effect it may be deferred that the maximum achievable **static efficiency** covering both **bell-mouth inlet and diffusor** is around **73%** in general and around **63%** for a 500mm impeller.

2. What is the relationship between compliance and different configurations linked to rpm and/or stator (bell-mouth vs. orifice)?

In this section, suggestions for Tier III and Tier IV targets will be suggested taking into account an orifice set-up, bell mouth set-up, motor poles and bell-mouth option with diffusor. Targets and compliance status estimations covers measured axial impeller performance in an orifice set-up, a bell mouth-set up, IE3 minimum requirements and assumes a direct drive arrangement.

As mentioned Multi-Wings test experience shows that the maximum efficiency in **orifice** is around **56%** in general and around **48%** for a 500mm impeller.



Simple illustration of Pmax impeller in orifice. Source ISO 5167-2 and own picture.

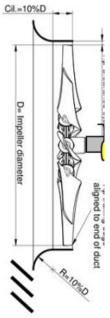
With the suggested N44 and N48 values for discussion, it will be possible to meet the targets with a 4-pole motor in compliance with IE3 together with a super-efficient impeller 558mm. However, not with other pole motors / speeds. Further, it will not be possible to comply with a 500mm and below with any of the motor poles.

							44	48
Impeller mm	Motor poles	STATOR	STATIC Efficiency of IMPELLER (Q*Ps/*Abs. Mech. power*)	Efficiency of FAN (Std A)	Efficiency Target ErP 2013	Efficiency Target ErP 2015	Efficiency Target ErP 2018	Efficiency Target ErP 2020
558	4	Orifice	0.52	**35.90%**	27.0%	31.0%	33.0%	35.0%
558	2	Orifice	0.52	**34.3%**	27.2%	31.2%	33.1%	35.3%
558	6	Orifice	0.52	**34.1%**	27.2%	31.2%	33.1%	35.3%
558	8	Orifice	0.52	**32.2%**	27.3%	31.3%	33.4%	35.7%
500	4	Orifice	0.48	**36.8%**	30.7%	34.7%	38.1%	42.1%
500	2	Orifice	0.48	**36.4%**	30.8%	34.8%	38.1%	42.1%
500	6	Orifice	0.48	**35.6%**	30.8%	34.8%	38.2%	42.2%
500	8	Orifice	0.48	**34.4%**	30.9%	34.9%	38.3%	42.3%

However, lowering the N values to N41 and N42 will enable compliance for smaller diameters with a 2 and 4-pole motor.

							N	N
							41	42
Impeller mm	Motor poles	STATOR	STATIC Efficiency of IMPELLER (Q*Ps/*Abs. Mech. power*)	Efficiency of FAN (Std A)	Efficiency Target ErP 2013	Efficiency Target ErP 2015	Efficiency Target ErP 2018	Efficiency Target ErP 2020
558	4	Orifice	0.52	**35.90%**	27.0%	31.0%	30.0%	30.5%
558	2	Orifice	0.52	**34.3%**	27.2%	31.2%	30.1%	30.7%
558	6	Orifice	0.52	**34.1%**	27.2%	31.2%	30.1%	30.7%
558	8	Orifice	0.52	**32.2%**	27.3%	31.3%	30.4%	30.9%
500	4	Orifice	0.48	**36.8%**	30.7%	34.7%	35.1%	36.1%
500	2	Orifice	0.48	**36.4%**	30.8%	34.8%	35.1%	36.1%
500	6	Orifice	0.48	**35.6%**	30.8%	34.8%	35.2%	36.2%
500	8	Orifice	0.48	**34.4%**	30.9%	34.9%	35.3%	36.3%

As mentioned, Multi-Wings test experience shows that the maximum static efficiency with a **bell-mouth** (R/D=10) and outlet covering the impeller is around **63%** in general and around **53%** for an 500mm impeller.



Simple illustration of axial airfoil impeller with bell-mouth.

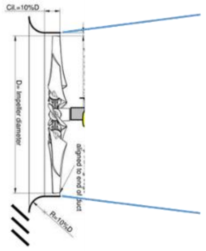
With the suggested N44 and N48 values for discussion it will be possible to meet the target with an 2-8 pole motor in compliance with IE3 and a super-efficient impeller 558mm. However, it will not be possible to comply with N48 using a 500mm and smaller diameter with any of the motor poles.

							N 44	N 48
Impeller mm	Motor poles	STATOR	STATIC Efficiency of IMPELLER (Q*Ps/*Abs. Mech. power*)	Efficiency of FAN (Std A)	Efficiency Target ErP 2013	Efficiency Target ErP 2015	Efficiency Target ErP 2018	Efficiency Target ErP 2020
558	4	Bell Mouth	0.58	**40.7%**	27.3%	31.3%	33.4%	35.7%
558	2	Bell Mouth	0.58	**38.8%**	27.5%	31.5%	33.6%	35.9%
558	6	Bell Mouth	0.58	**38.7%**	27.5%	31.5%	33.6%	36.0%
558	8	Bell Mouth	0.58	**36.5%**	27.6%	31.6%	33.8%	36.3%
500	4	Bell Mouth	0.53	**40.7%**	30.3%	34.3%	37.4%	41.4%
500	2	Bell Mouth	0.53	**40.2%**	30.3%	34.3%	37.5%	41.5%
500	6	Bell Mouth	0.53	**39.4%**	30.4%	34.4%	37.6%	41.6%
500	8	Bell Mouth	0.53	**38.0%**	30.5%	34.5%	37.7%	41.7%

However, keeping N44 and lowering N48 to N45 will enable compliance for smaller diameters with a 2 to 6 pole motor.

							N 44	N 45
Impeller mm	Motor poles	STATOR	STATIC Efficiency of IMPELLER (Q*Ps/*Abs. Mech. power*)	Efficiency of FAN (Std A)	Efficiency Target ErP 2013	Efficiency Target ErP 2015	Efficiency Target ErP 2018	Efficiency Target ErP 2020
558	4	Bell Mouth	0.58	**40.7%**	27.3%	31.3%	33.4%	34.0%
558	2	Bell Mouth	0.58	**38.8%**	27.5%	31.5%	33.6%	34.2%
558	6	Bell Mouth	0.58	**38.7%**	27.5%	31.5%	33.6%	34.2%
558	8	Bell Mouth	0.58	**36.5%**	27.6%	31.6%	33.8%	34.4%
500	4	Bell Mouth	0.53	**40.7%**	30.3%	34.3%	37.4%	38.4%
500	2	Bell Mouth	0.53	**40.2%**	30.3%	34.3%	37.5%	38.5%
500	6	Bell Mouth	0.53	**39.4%**	30.4%	34.4%	37.6%	38.6%
500	8	Bell Mouth	0.53	**38.0%**	30.5%	34.5%	37.7%	38.7%

As mentioned, from Multi-Wings experience and assuming 10% in Diffusor effect it may be deferred that the maximum achievable static efficiency covering both bell-mouth inlet and diffusor is around **73%** in general and around **63%** for a 500mm impeller.



Simple illustration of axial airfoil impeller with bell-mouth and diffusor.

With the suggested N44 and N48 values for discussion, it will be possible to meet the target in all cases covered.

ADDED 10% for assumed Diffusor effect

0.1 N N

Impeller mm	Motor poles	STATOR	STATIC Efficiency of IMPELLER (Q*Ps/*Abs. Mech. power*)	Efficiency of FAN (Std A)	Efficiency Target ErP 2013	Efficiency Target ErP 2015	Efficiency Target ErP 2018 (44)	Efficiency Target ErP 2020 (48)
558	4	Bell Mouth	0.68	**47.6%**	27.3%	31.3%	33.4%	35.7%
558	2	Bell Mouth	0.68	**45.5%**	27.5%	31.5%	33.6%	35.9%
558	6	Bell Mouth	0.68	**45.3%**	27.5%	31.5%	33.6%	36.0%
558	8	Bell Mouth	0.68	**42.7%**	27.6%	31.6%	33.8%	36.3%
500	4	Bell Mouth	0.63	**48.4%**	30.3%	34.3%	37.4%	41.4%
500	2	Bell Mouth	0.63	**47.7%**	30.3%	34.3%	37.5%	41.5%
500	6	Bell Mouth	0.63	**46.8%**	30.4%	34.4%	37.6%	41.6%
500	8	Bell Mouth	0.63	**45.2%**	30.5%	34.5%	37.7%	41.7%

3. Do fan selections distinguish themselves from the best efficiency point?

AMCA International has compiled a Fan Database with more than 1 million fan orders that among other enables running regulatory impact assessments. Analysis of the AMCA Fan Database expresses that average selections are **fare away** from peak efficiency and that far **greater savings** may be achieved by focusing on the **selection point** instead of the best efficiency point.

To promote that savings are controlled by selection and not any arbitrary point AMCA International has helped support the development of a new fan efficiency metric expressed as PEBR (Performance Efficiency Based Ratio) / FER (Fan Efficiency Ratio) elaborated in detail in "Introducing Fan Efficiency Ratios". The White paper is available free at www.amca.org/whitepapers.

For further info about both the data base analysis and metrics, I recommend contacting Wade Smith, Executive Director, Mark Stevenson, Deputy Executive Director and responsible for technical operations or Michal Ivanovich, Director of Industry Relations. For contact, info see http://www.amca.org/about/staff.php.

4. Are stand-alone performance predictable when integrated into other products?

Fans are incorporated and build into a diverse range of products covering among other oil coolers, cooling towers, snow canons, industrial radiators, dry coolers, gas coolers, air cooled steam condensers and incubation systems etc. A widespread belief have been that pressure losses and noise generation in aerodynamic systems can be pre-calculated with a fair degree of accuracy. However, the publication “Eurovent 1/12 Sources in Aerodynamic System Resistance and Acoustic Calculation” (Eurovent 1/12) expresses that this is not the case and flow patterns are much too complicated to allow this.

The Eurovent 1/12 study expresses that:

- In most installations the flow is neither laminar nor fully turbulent but at an intermediate state.
- Resistance coefficients given in literature, which form the basis of all calculations, do not normally take different flow modes or patterns into account at all and therefore cannot be expected to be very accurate.
- That impellers not integrated in a simple fan alone is strongly impacted by the aerodynamic interaction of components involved within the system.
- This may have negative effects on the power consumption and the noise level of the installation.
- Under or over evaluation of losses will lead to airflows differing from the design optimum with negative **cost implications** and **adverse consequences** for the processes concerned.

This means that even a careful pre-calculation of the expected pressure losses in a system may lead to results that differ considerable from the actual values found in the system when built. In other words, even if a Super ErP fan was the starting point for the design of a non-fan product there is no guarantee that the fan and non-fan product will be fully matched. Obviously, forming policies for fans integrated and build-in other products is uncertain and risky when there is a disconnection between fan efficiency optimization and system efficiency optimization, which may lead to unwarranted and adverse outcomes. However, the complexity of system effects may be addressed and system optimization promoted by:

- Minimum efficiency requirement linked to the final functionality
- Allowance for differences in testing and installation set-up for fans to counter the complexity of system effects.
- Considering range efficiency instead of peak efficiency at the design point

5. Does a defined set-up for axial impellers exist?

At the second stakeholder meeting the opportunity for an alternative approach when the final stator is unknown was expressed. This suggestion was based on a defined stator covering an Orifice set-up with reference to ISO 5801. This is different from the bell-mouth set-up suggested and elaborated to CEN, VHK and AMCA in a response to the absence of a general and established standard for axial impeller testing. This gap and the possible solution has been discussed with fan experts in EU and US long before the EU Fan Regulation Review started. So, now the justification for the reference to ISO 5801 is requested to learn from the existing standard text.

Mark Stevenson, Deputy Executive Director, AMCA International and contributor to ISO 5801 confirms that the standard does not cover a defined testing set-up for axial fan impellers. Obviously, ISO 5801 in Annex A not part of the standard (normative) covers an reference that underlines that the requirements

for an orifice plate between two sections of an airway and for simplified installations in, which they may be used and which refers to ISO 5167-2. On the other hand, it does not cover axial impellers designed to operate with a casing such as for example airfoil impellers c.f. Woods practical guide to fan engineering and Fan and Ventilation – a practical guide by Cory.

Propeller fans may be regarded as a special type of axial fan designed to operate without a housing in a wall or partition. Blades for that special design and simplified installations is optimized to operate with an orifice flow pattern or vortex formation. While, these special blade designs does the job well with orifice flow pattern it is not able to achieve as high fan efficiency as axial impelled optimized for use with a diffusor and / or housing. If an rounding is enlarged into a true bell mouth and a short tunnel is formed around an axial impeller, the fan becomes in effect an axial fan, and is better served by an airfoil section impeller c.f. Fans & Ventilation A Practical Guide by WTW (Bil) Cory and Multi-Wings design and test database.

So, Multi-Wing recommends:

- That an default test-set up is defined for orifice
- That an default test-set up is defined for bell-mouth
- Distinct efficiency requirement that matches the different needs that propeller and axial fan design meets together with distinct maximum achievable efficiency levels

If a simplified approach is needed. Multi-Wing for the purpose of 327/2011 recommends a bell-mouth set-up and one target.

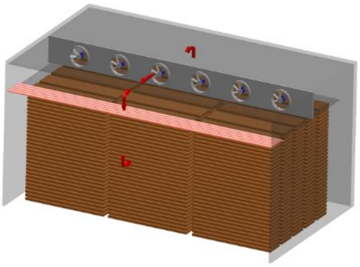
6. What is the challenge with truly reversible fans?

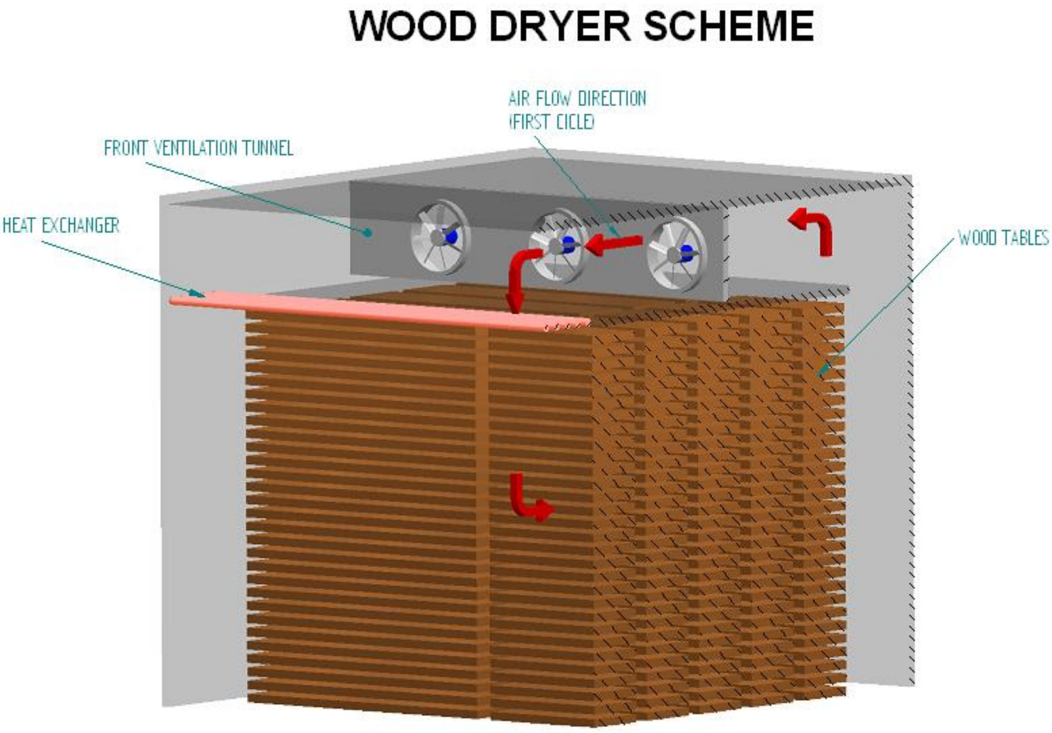
Multi-Wing supplies truly reversible fans to wood drying and brick / tile drying manufacturers in Europe. The solutions we offer help these manufacturers meet ErP2015. However, the solutions will not be able to meet higher requirements. Hence, Multi-Wing highly recommends that targets should not increase for truly reversible impellers used for drying applications where reverse flow is needed.

A truly reversible impeller can be built from standard parts by rotating every other blade through 180 degrees. Half will then be running nose-first and half tail-first, the volume flow being 85% of normal in each direction c.f. woods practical guide to fan engineering.

I have asked why these manufactures don’t shift to two fans with higher efficiency. That could be good for them (Multi-Wing and other fan manufacturers). The reply from of our Market Managers was that this was the approach in the old days. However, when drying several fans are already placed side by side all running. The fans are not run for a short time in the other direction. All the fans are needed to run in a systematic way that is reversed to ensure a uniform drying. It it not good if for example the wood is “115%” dry on the one side and some spots are “85%” dry..

Next page illustrated pictures of a standard layout for a wood dryer and for brick drying:




WOOD DRYER SCHEME
AIR FLOW DIRECTION
(FIRST CICLE)
FRONT VENTILATION TUNNEL
HEAT EXCHANGER
WOOD TABLES


Brick Industry

7. What is challenge with not allowing non-ventilation manufacturers to estimate overall fan efficiency and input power?

A challenge for most non-ventilation manufacturers if not allowed to estimate the overall efficiency and input power is the testing cost. Producers of non-fan products with fans incorporated and/or driven impellers build in have test equipment for testing their products final functionality. However, most of these manufacturers do not have the equipment or personnel to test fan performance.

Indicative but bot representative estimated testing charges (US$) received for a specific request more than year ago from a third party testing authority for non-members where approximately:

Fan diameter in mm	500	1000	1500	2000
Total:	$1755	$2085	$2640	$2640

The expenses may be severe for non-fan producers without a wind tunnel for fan testing and who has an excessive range and/or tailor makes products sold in one or small volumes.

While, direct measurement of fan system performance is preferred, the large variety of fan system configurations makes this both impractical and costly. The cost might become a barrier for both tailor made products and a wide variation among standard products.

Here, it is worth noting that, an estimation method based on both impeller and motor data from suppliers is in accordance with the alternative position of EUROVENT Product Group Fans C.f. PP - 2014-07-09 - Extended Eurovent Position on 'Fan Definitions' and the Regulation Scope.pdf

Alternative position on 'not complete assemblies'

> Fans integrated into other products may be built up using non-complete assemblies (e.g. impellers, motorised impellers, as well as impeller and scroll assemblies). In this case, the Declaration of Conformity of the complete incorporated fan may refer to the performance achieved by some non-complete assemblies, as tested or calculated by the original manufacturer of the non-complete assembly, using a nominal set of 'missing essential parts', not on the efficiency of the fan completed with parts of other design or characteristics.
>
> The calculated efficiency may be based on the efficiency of the actual motor used at its actual load when driving the fan at its best efficiency duty point.

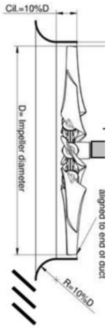
Source: Page 5 in PP - 2014-07-09 - Extended Eurovent Position on 'Fan Definitions' and the Regulation Scope.pdf published 9th July 2014 on http://www.fanreview.eu/documents.htm.

8. What are the potential design challenges in general with tight space constraints and for oil coolers / radiators?

Obviously, the final EU Fan Regulation review updated regulatory text is needed to assess the final targets and design implications. However, the potential impact compared to the initial text should be considered together with among other that impellers will potentially be out of scope together with targets potentially set so high, that redesigns of non-fan products may be the only outcome in some cases.

To reach very high targets could require shifting to larger fans, bell mouth inlet, diffuser and changing fan type.

Adding a bell-mouth will approximately require an additional space of 20% of the impeller diameter compared to an orifice plate. For an 800mm impeller that means and additional space of 160mm. Obviously, 160mm may not appear as much but may be problematic with very tight space conditions. In addition, in very tight conditions with an obstruction at the fan outlet adding a bell-mouth solutions if possible will likely only add to cost and not performance due to flow framework conditions.



Picture of short housing with bell-mouth inlet

In addition, to extra space to substitute an orifice solution with a bell-mouth solution extra space is also needed to capitalize from the improved fan technology. This is because the distance between the fan and the radiator has an influence on the airflow. The aerodynamic and acoustic system effects of a fan installed in front of a heat exchanger are quite significant when the distance from the exchanger to the fan is lower than about 0.2 D impeller diameter. This is valid for axial and centrifugal fans. Hence, it is therefore recommended to keep a distance of at least 0.2 D between the two elements C.F. EUROVENT 1/12.

An example will help illustrate the design challenges with integrating a bell-mouth instead of an orifice when working under tight space constraints.

Imagine a radiator / Oil Cooler with a wide of 549mm. If the customer has to use a bell-mouth, which should be 12% of the diameter, then the radius of the bell-mouth is 60mm on each side. Since the manufacturer only has 549 mm space for the complete set-p, it is required to reduce the fan diameter from 549mm to 418mm. The orifice and bell-mouth fan is optimized based upon a requested design point from the manufacturer. In addition, a distance between fan and coil was recommended to be 0.25 D. However, space constraints only allowed 0.10 D. The result from a concrete exercise optimizing from the design point and not from the best-efficiency point expressed:

	Potential Power Saving	**Increased stator depth**	**Distance to exchanger**	**Min needed distance between fan & exchanger**	**Space shortage**
Design Point	14%	.2D / 83.6mm	-33.6mm	83.6mm	-117.2mm

Source: Own Calculations and wind-tunnel experiments.

So, while it was possible to reduce the fan diameter to respect existing space constraints in the width and gain an efficiency benefit it was not possible to maintain the depth. In fact, the solution came out exceeded the existing space with 33.6mm. In addition, to the 33.6 mm short, there was still a need of minimum 83.6 space between the fan and radiator (0.2D). Hence, the design concept came 117.2mm short.

Adding a diffuser will approximately require an additional space of minimum .2 of the impeller diameter and up to 1.5 of the impeller diameter. Design among other dependent upon type of flow, diffuser angles, length and needed static pressure. For an 800mm impeller that means and additional space of minimum 160mm and up to 1600mm. So, together with a bell mouth that means between 320mm and up to 1760mm.

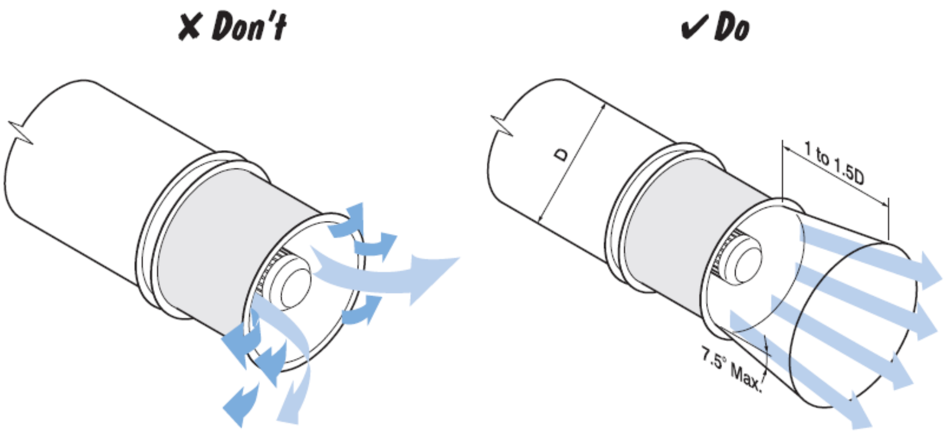
Below example of diffuser guideline and diffuser solutions:
@FANTECH 2008 expresses a diffuser length of 1-1.5 of diameter.

INSTALLATION DO'S AND DON'TS

1.0 AXIAL FANS (Cont.)

Figure 1.5. - Pressure recovery

Look for opportunities for static pressure recovery at axial exhaust fan outlets.



To determine the system resistance the discharge losses have to be added before selecting the fan.

Discharge losses are highest in this arrangement and are equivalent to one velocity head.

With a correctly designed discharge diffuser the pressure recovery in the diffuser will reduce the system total pressure.

Included angle of diffuser to be 15° or less.

Discharge losses reduced substantially in this arrangement.

Ebm-past website / EC_medium_pressure_axial_fans_2014-02.pdf & own calculations expresses a diffuser that is about 0.3D.

Impeller diameter	800
Impeller diameter *1.01	808

mm	404	0.5	1.5

0.9	0.3	242.4	mm
0.6	0.2	161.6	mm

0.3	3
0.1	1
80.8	808
mm	mm

Below expresses that the solution may easily be retrofitted to an existing solution with open space.

The new AxiTop diffuser can easily be retrofitted to existing systems such as this one.

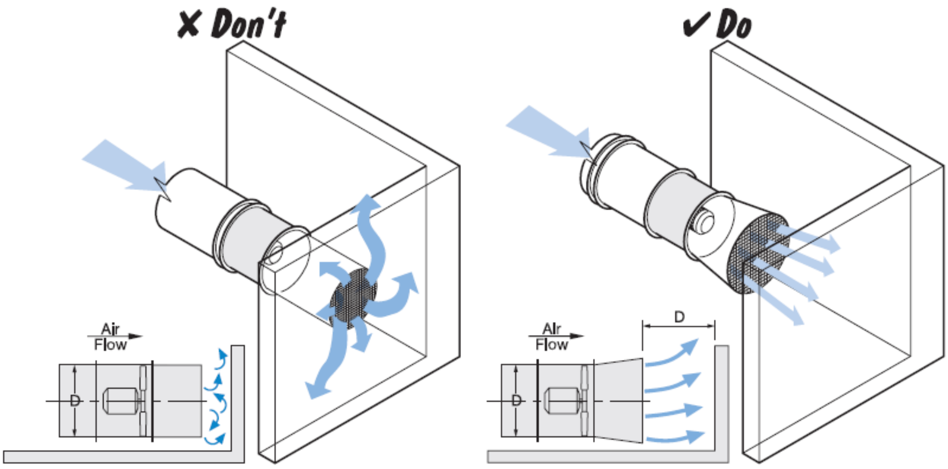
Source: ebm-past website / EC_medium_pressure_axial_fans_2014-02.pdf

As mentioned, adding a diffuser will approximately require an additional space of minimum .2 D of the impeller diameter and up to 1.5 of the impeller diameter. For an 800mm impeller that means and additional space of minimum 160mm and up to 1600mm. So, together with a 160mm for a bell-mount that amounts to an additional length space requirement between 320mm and 1760mm.

Obviously, between 320 and 1760mm may not pose an critical design challenge in above solutions with plenty of outdoor space. However, it may be a severe challenge with very tight space conditions as the example with an oil cooler / radiator illustrated. In addition, in very tight conditions with an obstruction at the fan outlet adding a bell-mouth solutions if possible will likely only add to cost and not performance due to flow framework conditions.

For example @FANTECH 2008 expresses to allow a gap of at least one fan diameter between fan outlet and obstruction and fit a diffusor on the discharge. Again, EUROVENT 1/12 expressed to allow minimum 0.2 D between a fan and an exchanger.

Figure 1.6. - Obstruction at fan outlet
Don't obstruct fan outlet.

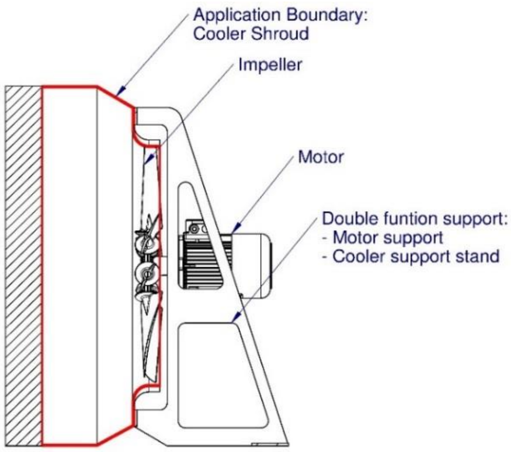


When the discharge is too close to a wall the obstruction generates noise and increases discharge losses.

Allow a gap of at least one fan diameter between fan outlet and obstruction and fit a diffuser on the discharge.

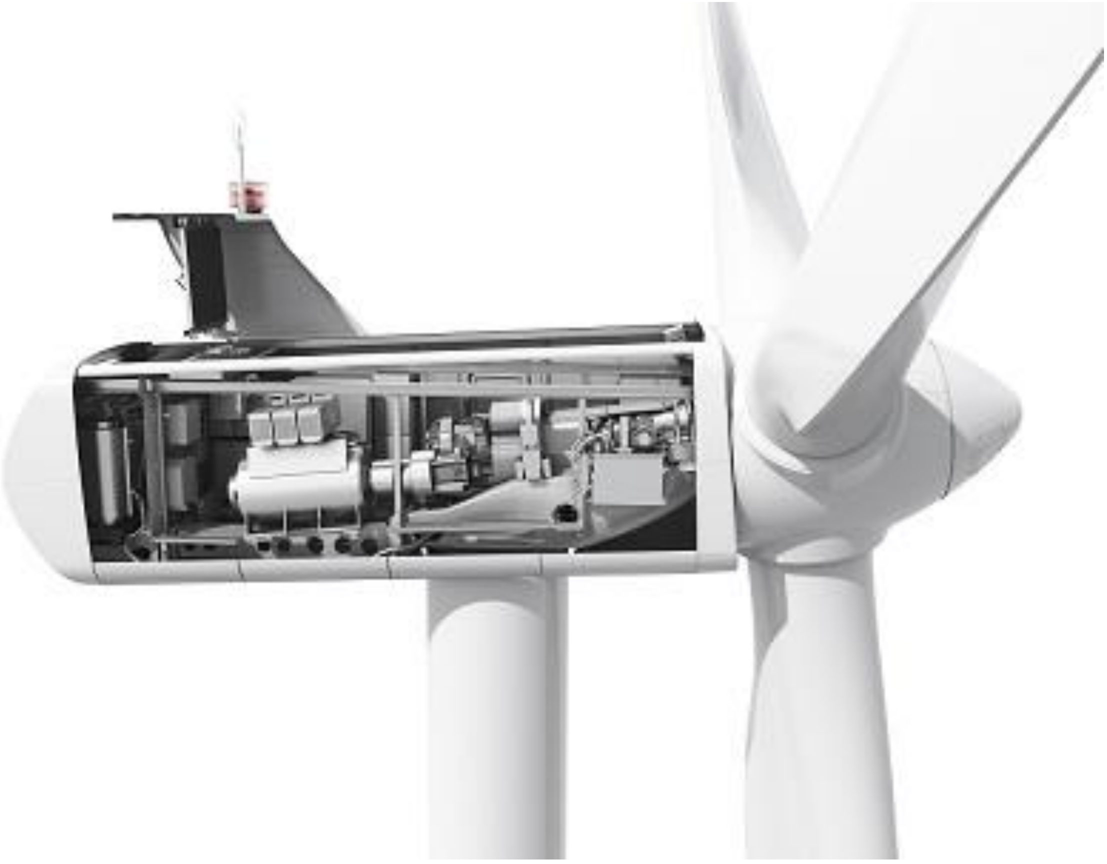
So, to reach very high targets could require shifting to larger fans, bell mouth inlet, diffuser and changing fan type. So, the questions becomes; what would the impact from larger units be for our customers and end users? May a change in the "housing" design for example make some applications unfit for incorporation into applications upstream? What share of improvements validated under wind-tunnel conditions will disappear in the field due to space constraints? Also, will it improve the final functionality of products with a different main functionality than a fan that needs to balance different necessities? How will it change the life cycle costs of the products? May it impact industry competitiveness significantly negative? Will it impose excessive administrative burdens on manufacturers? There are many unaddressed questions. To optimize environmental impact an effort and clear guidelines are needed for applications working far away from the best efficiency point and/or under severe space constraints, where there also is a need for minimum efficiency requirements.

One example of an application with a driven impeller installed in an orifice and working under tight space constraints is an oil cooler not enabling fully developed flow. Below is an illustration of an oil cooler.



Adding a bell-mouth will add significantly to the overall static efficiency when measured in wind tunnel with smooth flow conditions. However, due to the actual installation conditions the lab effect will not necessarily translate into a field effect or allow installation due to space constraints determined upstream. The obvious solution is to change the design of the oil cooler to enable meeting the EU Fan Regulation adding a diffuser and/or bell-mouth. However, the key challenge is that the oil cooler is integrated or build into conditions with very tight space. Oil coolers are for example integrated / build into the tower and house of wind turbines as well as some on-/-off road equipment.

Picture of a windmill tower



Picture of a typical Nacelle illustrating the space situation.

Picture of on/off-road machine with an electric driven fan on their oil coolers

Conclusion & Policy Recommendations

Efficiency of an impeller in an orifice may be improved significantly by adding a diffuser and/or bell-mouth. However, it must be kept in mind that products with fans incorporated or axial impellers build in are confronted by different space constraints; different policies are needed to ensure meaningful and strict efficiency requirements in the future unless the intention is to for example require bigger wind turbine towers, wind turbine houses and on-/-off equipment.

Summing up and considering that fans are used outside the peak efficiency point, Multi-Wing recommends the following targets, exemptions and distinctions:

EU FAN REGULATION REVIEW RECOMMENDATIONS FOR AXIAL IMPELLERS			
Efficiency Ratio	• Maintain current ISO 12759 Metrics (Best Efficiency) and definer higher targets for ventilation and lower for non-ventilation applications, or • Introduce Application Dependent FER Metric (Design Point) by AMCA International www.amca.org/whitepapers		
Suggested Targets for current metric and axial fans measured with free inlet and free outlet (A)			
	Designed for / Space availability for	**2018**	**2020**
Detailed Recommendation	Orifice installation	N40	N42
	Housing / Bell-mouth installation	N43	N44
	Housing / Bell-mouth + Diffusor installation	N44	N48
	Truly reversible fans	N40	N40
Simplified Recommendation	Ventilation	N44	N48
	Non-Ventilation	N40	N42
	Truly reversible fans	N40	N40
Alternative test (default stator) for non-fan products (Build-in)			
Detailed Recommendation	Axial impellers designed to operate without housing		Default orifice
	Axial impeller designed to operate with housing		Default bell-mouth
Simplified Recommendation	If simplification is needed for purposes of regulation		Default bell-mouth
Fan efficiency Calculation			
Ventilation	Only direct measurement shall be allowed		
Non-Ventilation	Estimation method shall be allowed		
Fan Configuration Adjustments within non-fan products			
Shall be allowed to counter system effects and range efficiency instead of peak efficiency should be considered (ErP Optimal configuration shall be able to comply)			
Oil Coolers / Radiators			
Reduced targets when installation conditions are expressed by thight space contraints (e.g. wind turbines and on-/off road machinery)			

Multi-Wing highly appreciates the opportunity to comment. Obviously, 327/2011 is an important milestone to help protect our environment. However, 327/2011 can still be optimized to ensure an optimal impact covering the complexities from applications used outside peak efficiency, with tight space framework conditions and by manufacturers without wind tunnels and wind tunnel personnel.

Please, let me know if you have any comments or questions. All data is available upon request for VHK.

Sincerely,
Sham Morten Gabr