Fan EcoDesign implementation

Halifax Fan Ltd interpretation of Commission Regulation (EU) No. 327/2011 for implementing Directive 2009/125/EC – eco design requirements for fans driven by motors with electric input power between 0.125kW – 500kW

The regulation and directive recognise the total electrical consumption of fans driven by electric motors is at a level for which eco-design requirements should be established for the EU market to make a reduction of around 10% per year (34TWh) of current electrical consumption by 2020, corresponding to 16 million tonnes of CO_2 emissions.

The regulations requires us, as fan manufacturers, to provide technical information on our products against identified indicative benchmark target efficiency grades for different fan types.

The measurement of electrical absorbed power, hence energy efficiency, should be ascertained from a correctly established audit and prototype test program (BS848, ISO5801) under a recognised Quality Management System such as ISO9001:2008. This is very much in-line with Halifax's current design and manufacturing practices in both Brighouse and Shenzhen factories which both produce high efficiency bespoke fans for the global market.

The regulation recognises specifically Centrifugal Forward Curved, Centrifugal Radial Bladed & Centrifugal Backward Curved fan types (impeller design profiles). *Note that the regulation does not specifically mention Centrifugal Backward Inclined fan types*

In general, it should be noted that these regulations apply to fans with absorbed powers between 125W and 500kW; however, the regulations will not apply to:-

a) Fans designed to operate in potentially explosive atmospheres as defined in the 94/9/EC directive – ATEX
b) Fans handling operating temperature of gases exceeding 100^{o}C
c) Fans operating in ambient temperatures exceeding 65^{o}C
d) Fans operating in environments with average temperatures below -40^{o}C
e) Fans with drive motors having a supply voltage above 1kV AC
f) Fans operating in toxic, highly corrosive or flammable environments – *Halifax will also apply this to an application where a Backward Inclined Design is necessary for handling dust loads, in the absence of anything specific in the regulation related to dust handling & B.I. impeller design*
g) A fan intended as a spare (prior to 1st Jan 2015) to replace an identical product, providing it is labelled as such.
h) Conveying fans used for transporting non-gaseous substances in industrial process industries
i) Fans with a Specific Ratio MORE than 1.11 (ie approx. 44"WG open inlet centrifugal fan (1 bar absolute pressure x 1.11 = 110mbar Dp = 44"WG) - *Article 3, 4 (b)*

Definitions

It is proposed to implement the standard based on the following definitions which are taken by using Annex 2 as a guide:-

Centrifugal Radial Bladed fans : where the outward direction of the impeller blade at its periphery is radial relative to its axis of rotation.

Centrifugal Forward Curved fans : where the outward direction of the blade at its periphery is forward relative to its direction of rotation

Centrifugal Backward Curved fans : where the outward direction of the blade at its periphery is backward relative to its direction of rotation. *It is also noted that for clean air, this definition could also be applied to all Centrifugal Backward Inclined fans.*

Measurement Category A : refers to fan testing where no duct (free inlet and outlet)

Measurement Category B : where a duct is fitted to outlet only (free inlet)

Measurement Category C : where a duct is fitted to inlet only (free outlet)

Measurement Category D : where a duct is fitted to both inlet and outlet.

Overall Efficiency (η_e): This is a calculated from total efficiency, Pu and Pe. It is understood that all mention of efficiency is based around the fan's potential optimum total efficiency point of its curve, regardless of actual required duty point. $\eta e = \frac{Pu}{Pe}$

Target Efficiency: is the minimum energy efficiency the fan range must achieve based on Table 1 definition i.e. optimum total efficiency point of the curve, Pe, Efficiency Grade

Pe : Calculated power consumption. $P_e = \frac{P_{imp}}{(\eta_m \times \eta_T)}$

P_{imp} : Impeller power based on scaled readings measured during audit/prototype tests minus any losses for coupling/bearing etc, as defined in the selected test standard at optimum total efficiency point

Pu : Fan Gas Power calculated from q (fan volumetric flow, m3/sec at optimum Total efficiency point) multiplied by P (fan total pressure at optimum total efficiency point) and K_P (compressibility factor usually taken as 1)

$$Pu = q \times P \times Kp$$

η_m : Nominal rated motor efficiency, calculated as per 3.2

η_T : value of "1" for direct or in-line drives, "0.96" for belt drives

Implementation recommendations

1, Calculation Method 3.1(a) 'Final Assembly' without inverters should be adopted as fan manufacturers rarely include them and are not always aware of the end users starting/control methods.

2, As many fans from industrial centrifugal fan manufacturers are bespoke and individually designed for many varying applications, it is therefore not practical to publish the fan's overall efficiency for that manufacturer's entire range

3, As many fans from industrial centrifugal fan manufacturers are often designed to meet the over-capacity of their immediate customers/system designer without appreciation of actual required duty, it is not possible to accurately predict the installed power measurement.

4, Considering points 2 and 3 above, it is recommended to publish a single figure of "Overall Efficiency η_e" against "Target Efficiency η_{target}" for each of the manufacturers product ranges. These single figures will be based on a mean average of 3 example points from each range. The example points should be defined to try to give a realistic and fair operating scenario to cover each model range. Point 1 being a small fan size (approx. 400-500mm impeller diameter at 3000rpm direct drive). Point 2 being a medium fan size (900-1000mm impeller diameter at 2300rpm belt drive), Point 3 being a larger fan size (1600-1800mm impeller diameter at 1500rpm direct drive). Each point should be based on fans handling clean air at 20^{o}C and 1 atmosphere at fan inlet. Where these points are found to be outside practical operating range for individual manufacturers, or powers (Pe) outside the scope of this regulation, then adjust speed and drive type accordingly.

4, Published fan range "Overall efficiency η_e" figures to be included on CE certification

5, In the spirit of the regulation, where possible, for clean air applications, FMA members should be encouraged to offer Centrifugal Backward Curved types where significant efficiency gains can be made despite possible increases in cost over Backward Inclined types.

6, Concerns exist over how practical this regulation is with regard to the setting of the target Efficiency Grades for smaller powered units under 11kW and the FMA will look to seek amendments in line with motor efficiency and fan scale effect.

7, The regulations include increased efficiency targets as of Jan 2015, FMA encourages all member companies to step-up R&D on efficiency to meet and exceed the 2015 targets ahead of time

Worked Example

A 1m diameter Backward Curved fan supplied with fan case, v-belt drive and a 55 kW motor. Running speed 1600 rpm. Performance data based on Measurement Category D. According to Annex1 Table 1, Efficiency category is "total" and η_{target} is given by

$$\eta_{target} = 1.1 \times \ln(55) - 2.6 + 61 = 62.8\ \%$$

This is the target overall efficiency of the fan set required to meet first tier energy efficiency requirements.

At the point of "optimum total efficiency" the volumetric flow rate is 1.333 m^3/sec, fan total pressure is 3143.31 Pa and absorbed power (P_e) is 53.26 kW

Fan gas power P_u is given by 1.333 x 3143.31 x 1 = 41.9108 kW

To calculate the predicted electrical power P_e

$$P_e = \frac{P_{imp}}{(\eta_m \times \eta_T)}$$

From Annex II, where driver >0.75kW:

$$\eta_m = (0.000278 \times x^3) - (0.019247 \times x^2) + (0.104395 \times x) + 0.809761$$

$$where\ \ x = Log(55)$$

$$\eta_m = 0.001465 - 0.0583 + 0.1817 + 0.809761$$

$$\eta_m = 0.9346$$

For a v-belt drive classed as "low efficiency" η_T = 0.96

These gives $P_e = \frac{53.26}{0.9346 \times 0.96} = 59.36\ kW$

This gives an overall predicted efficiency of :-

$$\eta e = \frac{Pu}{Pe}$$

$$\eta_e = \frac{41.9108}{59.3600} = 0.706\ or\ 70.6\%$$

The fan in this example exceeds the efficiency target of 62.8%.