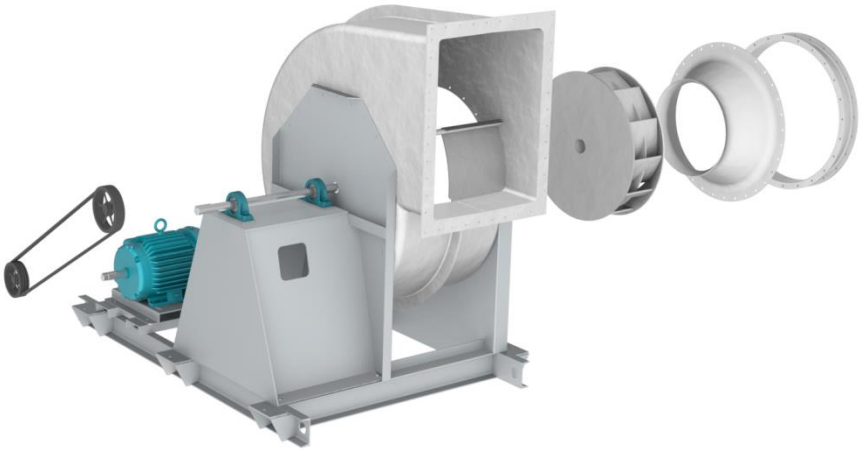
The DOE Fan Rule, Belt Driven Losses and Partial Width Fan Solutions for Waste Water Applications

The fan system is at the heart of odor capture and sequestration in a waste water treatment plant. Many different fan arrangements are currently used in order to satisfy the unlimited number of plant designs. A quick tour of the facility will show that many fans are belt driven. These fan systems can be installed on the clean or contaminated air side.



In 2016, the US Department of Energy will release the Commercial and Industrial Fan and Blower (CIFB) Regulation that will impact the waste water treatment industry. There are many facets to the rule, but this paper will focus on the benefits of direct driven, partial width fans, designs at synchronous speeds.

Designers use belt driven fans in order to accommodate the difference between the synchronous speed of the motor, and the design speed of the fan. Not all fans are designed at 3600, 1800, or 900 rpms. The ability to match duty points in the various water treatment systems with a sheave and belt system has allowed fan manufacturers to produce multiple performances with the same standard fan.

The new DOE regulation however will demand fans to meet the efficiency requirements at the design point of the water treatment system. The fan, motor and drive will have an allowable fan electrical power (FEP) consumption level. This means the DOE rule will calculate the allowable fan power consumption + the motor loss + the belt loss using the following equation:

$$\boldsymbol{FEP_{STD,i} = H_{\eta_{STD\,i}} + L_{Belt} + L_m}$$

Where:

$FEP_{STD,i}$ *= maximum allowable fan electrical input power kW at operating point i*

L_m *= Part Load Loss at full load efficiency*

$H_{\eta_{STD\,i}}$ *= Fan Shaft Power at operating point i*

L_{Belt} *= Belt Loss*

Under the new DOE regulation, the fan is always considered to have a motor and a belt drive. All fan default values will include a motor to drive the equipment (turbine driven fans, et al are excluded from the regulation) as well as a belt drive. It becomes obvious that if waste water fan system is not belt driven, it will not be penalized with a belt loss, and will automatically benefit. That is to say an arrangement 8 fan will be more efficient than the corresponding arrangement 9 fan. In regulatory terms, a direct driven fan/motor combination will comply with the DOE regulation better than a belt/fan/motor combination.

In the CIFB rule, the belt loss varies per the size of the motor. This can be seen in the Air Movement and Control Association (AMCA) Standard 203. The calculated belt loss in the DOE rule can range from 4%-10% of the fan system (Diagram1.) Simply put, a direct driven fan will have a 4%-10% advantage over the same belt driven fan. To calculate the belt loss, the below formulae can be used.

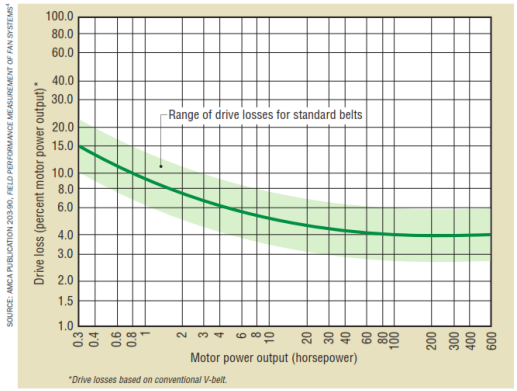
$$\eta_T = 0.96\left(1 - EXP(-(275 * H_{\eta_{STD}i})^{0.19})\right)$$

Where:
$H_{\eta_{STD}i}$ *= Fan Shaft Power at* η_{std}
η_T *= Transmission efficiency*

$$L_{Belt} = \frac{H_{\eta_{STD}i}}{\eta_T} - H_{\eta_{STD}i}$$

Where:
L_{Belt} *= Belt Loss*
$H_{\eta_{STD}i}$ *= Fan Shaft Power at* η_{std}
η_T *= Transmission efficiency*

Diagram 1



Quickly, the benefit for direct driven systems becomes apparent. In order to accommodate the difference between synchronous motor speeds and design points, fan manufacturers must now resolve the synchronous motor speed with partial width fans. This is accomplished by determining the fan specific speed at the design point and adjusting the impeller width accordingly.

Many fan companies lack the ability to produce partial width fans. It may be a lack of engineering protocols and standards or a lack in manufacturability. In either case, those fan companies will be at a distinct disadvantage with respect to the fan rule. It will eventually become necessary to shift fan specifications to account for this new reality. To accommodate plant aeration, odor control, sludge processing, and chlorine systems, Aerovent offers the BCF. The BCF composite fan is a backward curved industrial fan designed for handling particulate-free, corrosive or caustic air in high pressure applications seen in waste water applications. All of the parts that are exposed to the airstream are constructed of high-quality corrosion resistant materials to avoid material breakdown from most chemicals. The BCF features a wide wheel and housing, producing a high volume of air at a lower velocity. This fan can be designed direct drive and partial widths taking advantage of the new DOE fan rule. This offers compliance advantage to the water treatment facility by expanding the range of design points offered for sale.