NICOTRA Gebhardt

Variability of Fan performance, depending on Fan Case design

and consequences

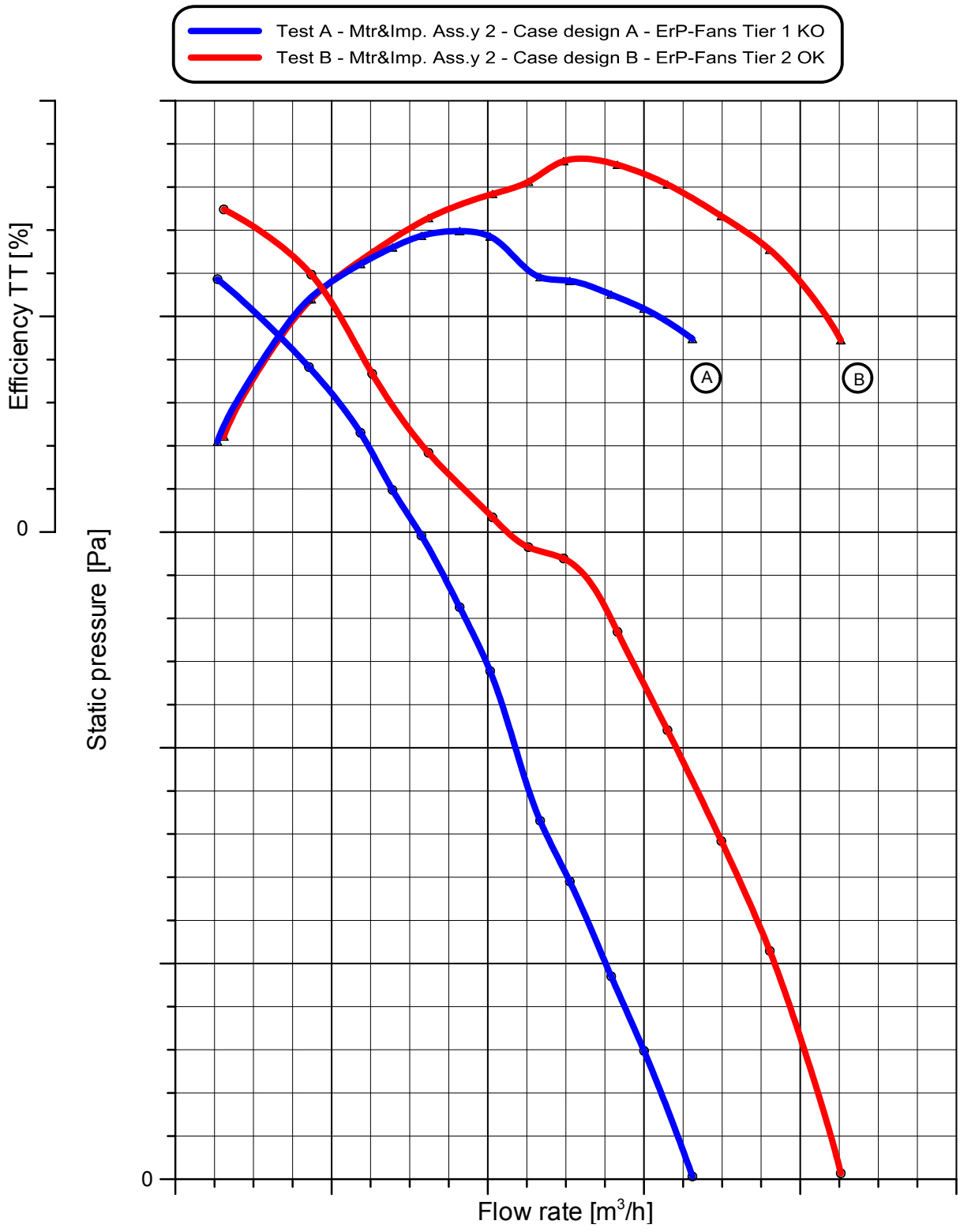
The performance of fans built-up using the same centrifugal impeller and motor, combined with alternative designs of the scroll-shaped housing, was recently tested as a part of a major project.

The exercise was obviously extended to the evaluation of the efficiency of the fan and its conformity to the requirements of the Reg. 327/11/EC, and was a clear confirmation of the significant dependency of the fan efficiency from the design of the surrounding scroll.

Case 1: <u>same centrifugal impeller and motor assembly</u>, combined with 2 different case designs:

Scroll-Case design A: fan NOT compliant with Reg. 327/11/EC Tier 1

Scroll-Case design B: fan Compliant with Reg. 327/11/EC **Tier 2**

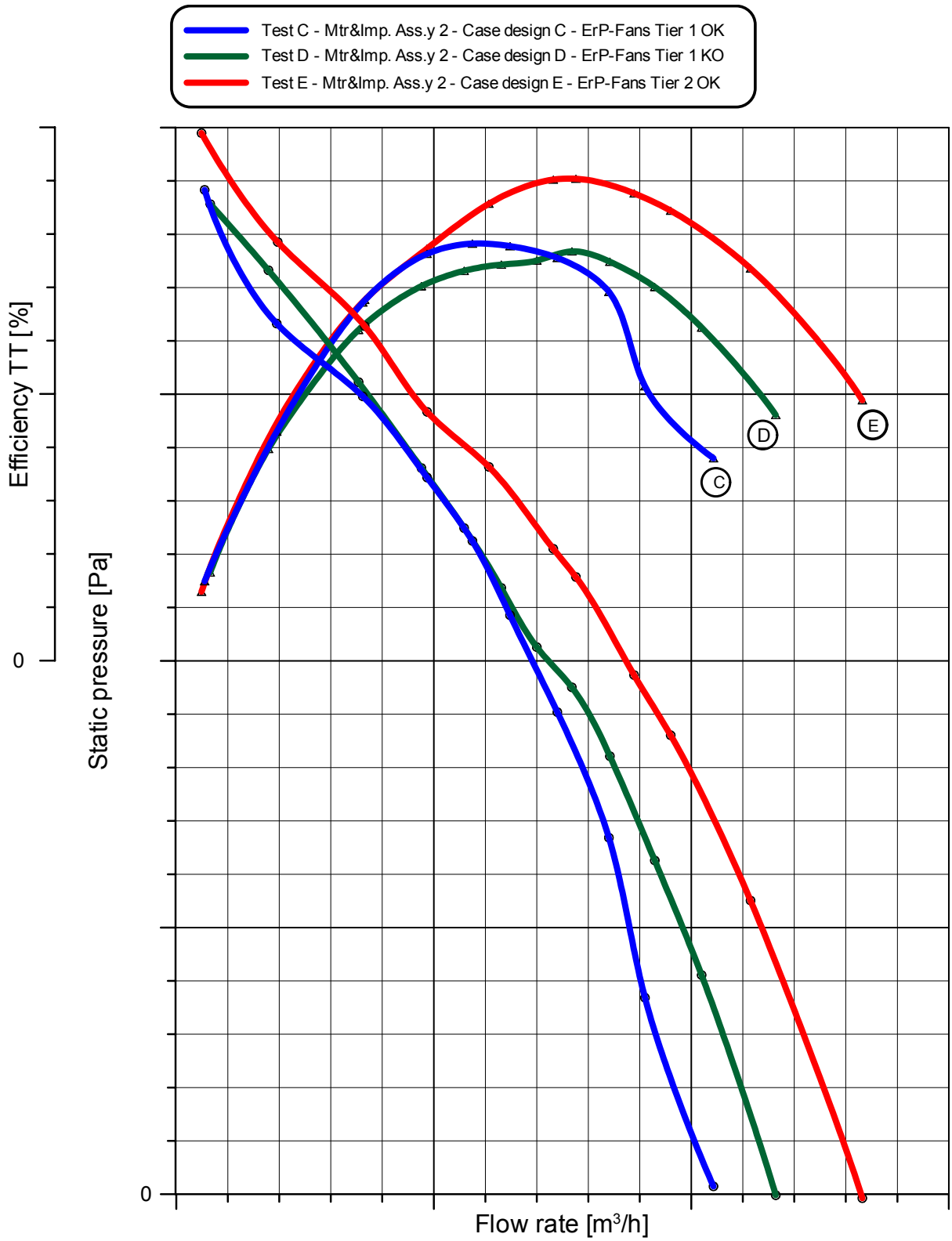


Case 2: <u>same centrifugal impeller and motor assembly</u>, combined with 3 different case designs:

Scroll-Case design C: fan Compliant with Reg. 327/11/EC Tier 1

Scroll-Case design D: fan NOT compliant with Reg. 327/11/EC Tier 1

Scroll-Case design E: fan Compliant with Reg. 327/11/EC **Tier 2**



Conclusions regarding the placing on the market of fan sub-assemblies:

These two clear examples demonstrate that the performance of a centrifugal fan is tied to the geometry and characteristics of both the main aerodynamic parts which interact with the airflow: the impeller (moving part) and the case or nozzle (stationary part).

This sensitivity of the fan performance and efficiency, to the pairing of the two parts, is not restricted only to centrifugal fans with scroll-shaped housing; axial fans are well known for having their performance heavily related to the design of their housing or case, and even plug-fans ("backward-curved centrifugal fans without housing") actually depend on the shape of the inlet nozzle leading the airflow into the impeller, notwithstanding its diminutive size, compared with a scroll-case.

The performance of the motor, in those cases where the motor is exchanging only mechanical power with the impeller, and does not interfere aerodynamically, can be combined with the performance of the aerodynamical parts through simple and reliable calculations, but the result of matching the impeller with alternative case designs can never be calculated reliably without recurring to extensive CFD simulations. Otherwise it has to be determined by measurement.

The energy efficiency of a fan impeller (whether combined or not with a motor) can be univocally measured only when a complete fan is assembled and test-run.

Testing standards like EN ISO 5801 do no define standard case designs, for testing impellers, whether centrifugal or axial, because complete fans may have to be designed for applications which impose different and conflicting design requirements for the case, as well as for the impeller. Defining the efficiency of the impeller as that one, which is measured in a specific kind of common, standardized housing, would effectively introduce a constraint to the future development of the fan designs, e.g. by preventing the development of new impellers, which may provide better performance only when fitted in new housing designs.

Leaving to the impeller manufacturer the responsibility of defining a nominal case design, for each impeller type, and then stating the impeller efficiency when combined with such a nominal design, is feasible, and is actually already a common industrial practice, but does not prevent "integrators" from adopting their own housing design, if they wish.

Accepting that compliance with an eco-design requirement for fans may be based on the measurement of the efficiency of the "nominal fan" only, which would be created by installing the impeller (with or without motor), into a nominal case design, is thus technically possible, but has significant drawbacks.

The main one is that such an approach would open a potentially dangerous loophole in the effectiveness of the regulation: fans non-compliant with the eco-design requirements could be assembled and legitimately sold by using impellers which might have been compliant, if such impellers had been used with the nominal housing design, but which are actually installed with a more compact housing, or a cheaper one, or one having larger gaps between rotary and stationary parts, resulting in a fan which is far from achieving the rated efficiency.

This approach would even lead to a clear distortion of the market, because fan manufacturers, delivering the complete fan, should be reasonably required to rate the efficiency of their product with reference to the configuration which is actually sold and delivered.

At the same time, “integrators” would be free to make their fans, for internal use as sub-assemblies into their own products, by adopting outsourced impellers and motors, which are compliant in their reference application, and combining them with internally-designed housings, still rating the new assembly with the efficiency of the nominal configuration, while the actually-built fan has a significantly different design and performance.

As one of the main arguments leading to the design of less-then ideal housings, in ventilation systems, is the need to reduce the physical size of the complete fan, this may be an effective incentive to the actual production and use of fans, which are rated to be compliant only in a completely artificial configuration, not representative of the product as effectively placed on the market, negating the goal of the regulation itself, while effectively allowing unfair competition.

For these reasons, it’s opinion of the Nicotra Gebhardt group that, in the interest of the effectiveness and fairness of the regulation, the compliance of a fan should evaluated according to its real combination of parts, and not just on a nominal design of the housing, with the fan being effectively built and placed on the market with a different design of its stationary composing parts.

It’s possible that an exception to this approach may be justified for specific cases, e.g. for larger-sized axial fans, where the burden of building and using a suitable test rig, to test every single arrangement of impeller and housing, may be considered impractical: In such a case, this exceptional approach should be clearly confined to those sizes or applications where the alternative approach is strictly necessary, to avoid giving the option of a devious and less demanding approach in too many possible applications of self-assembled fans.

Zingonia, 15th of January 2015