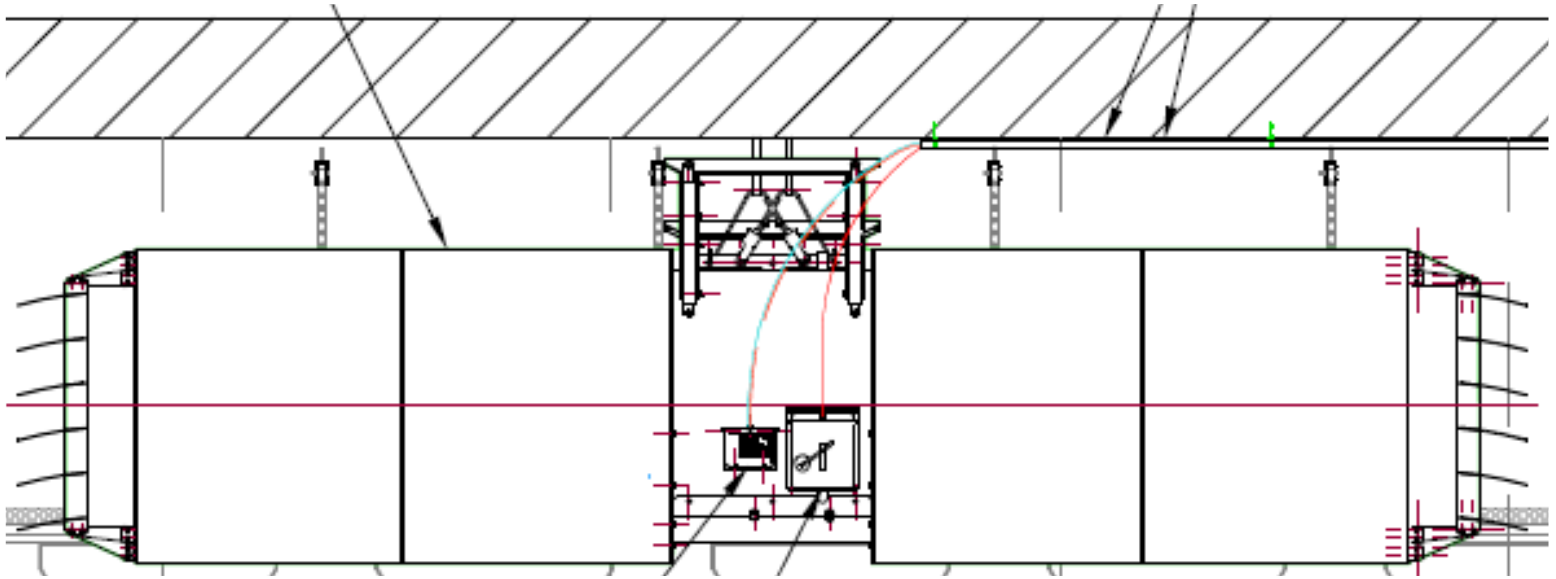
Deflectors for Tunnel Jet Fans



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Motivation

- Do deflectors improve the in-tunnel thrust of jet fans?
- What is the effect of deflectors on bench thrust, noise, power consumption, service life and tunnel environment?

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Contents

- In-tunnel thrust
- Bench thrust
- Noise
- Power consumption
- Structural integrity
- Jet throw
- Conclusions

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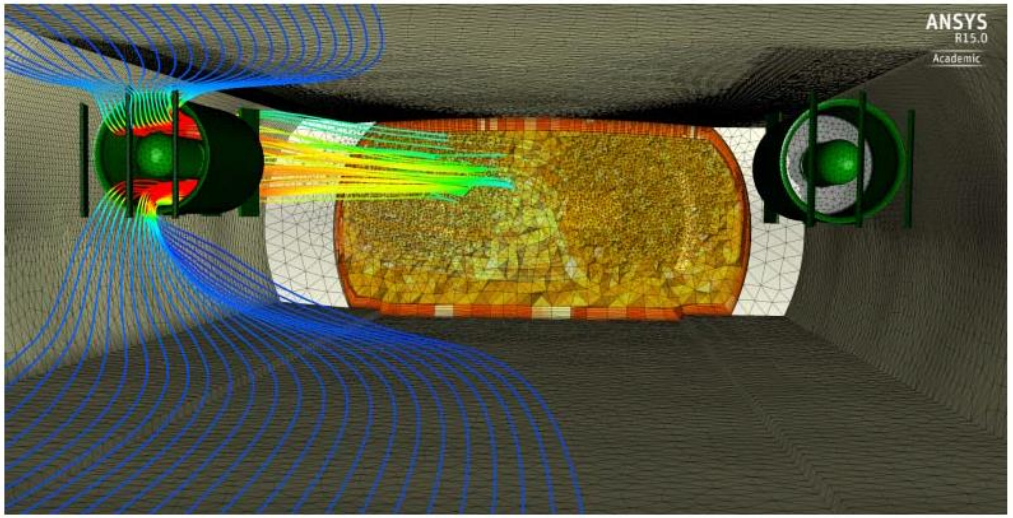
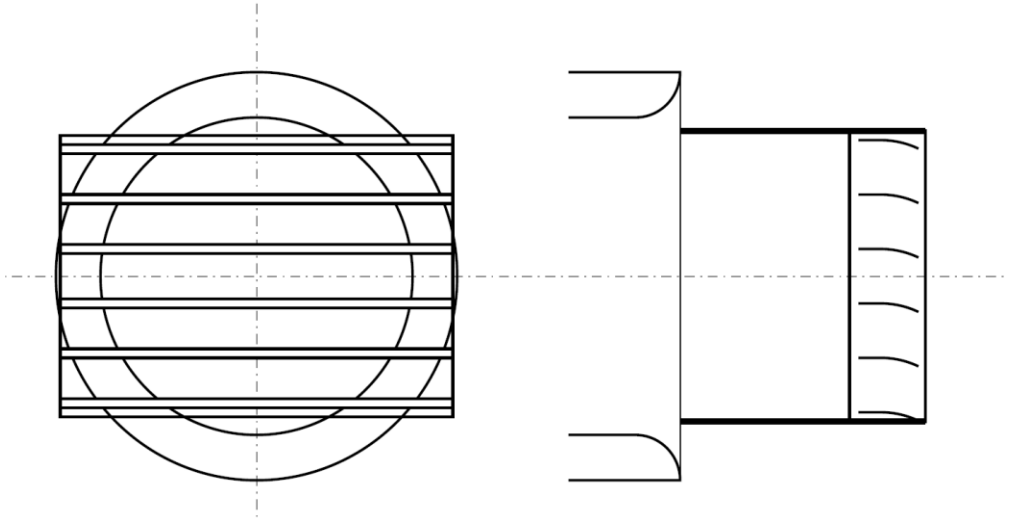
In-Tunnel Thrust

- Turning the flow from a jet fan can reduce the Coanda effect
- Research work by Lotsberg (1997) and Beyer et al (2016): deflectors can be effective in turning the discharge flow and in increasing the tunnel air velocity
- Beyer et al (2016) reported an improvement in in-tunnel thrust by up to 20%, with a vane deflection angle of 19°

Bosruck Tunnel, Austria



Experimental Measurements



- 710 mm internal diameter jet fan
- 2-pole motor running at 2970 rpm
- Blade pitch angle was set to 32°
- 1-D silencers installed on both sides of the jet fan
- Curved vanes with a deflection angle of 26°
- Rectangular and circular deflectors

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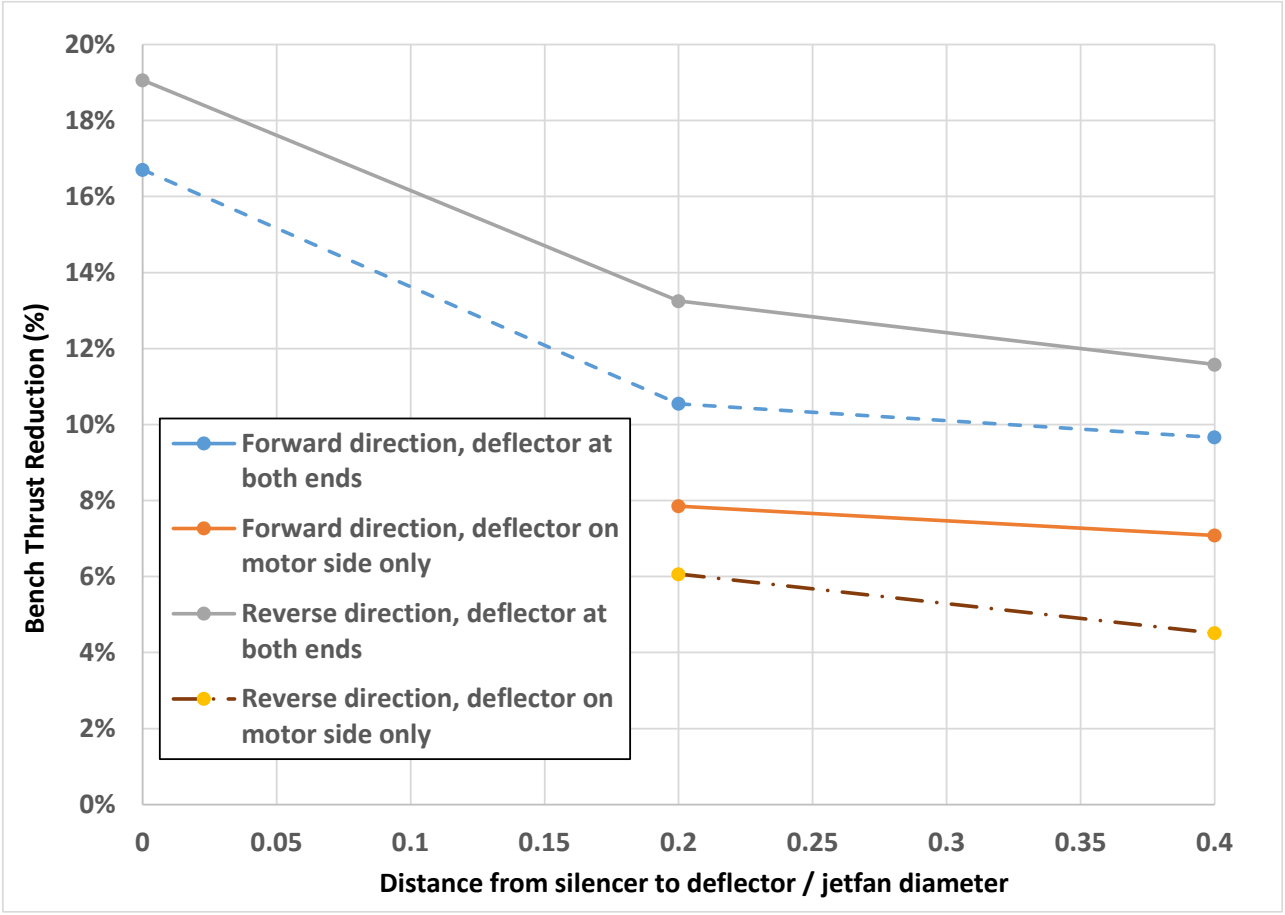
Bench Thrust Measurements



Measurements according to ISO 13350:2015 "Fans - Performance testing of jet fans"

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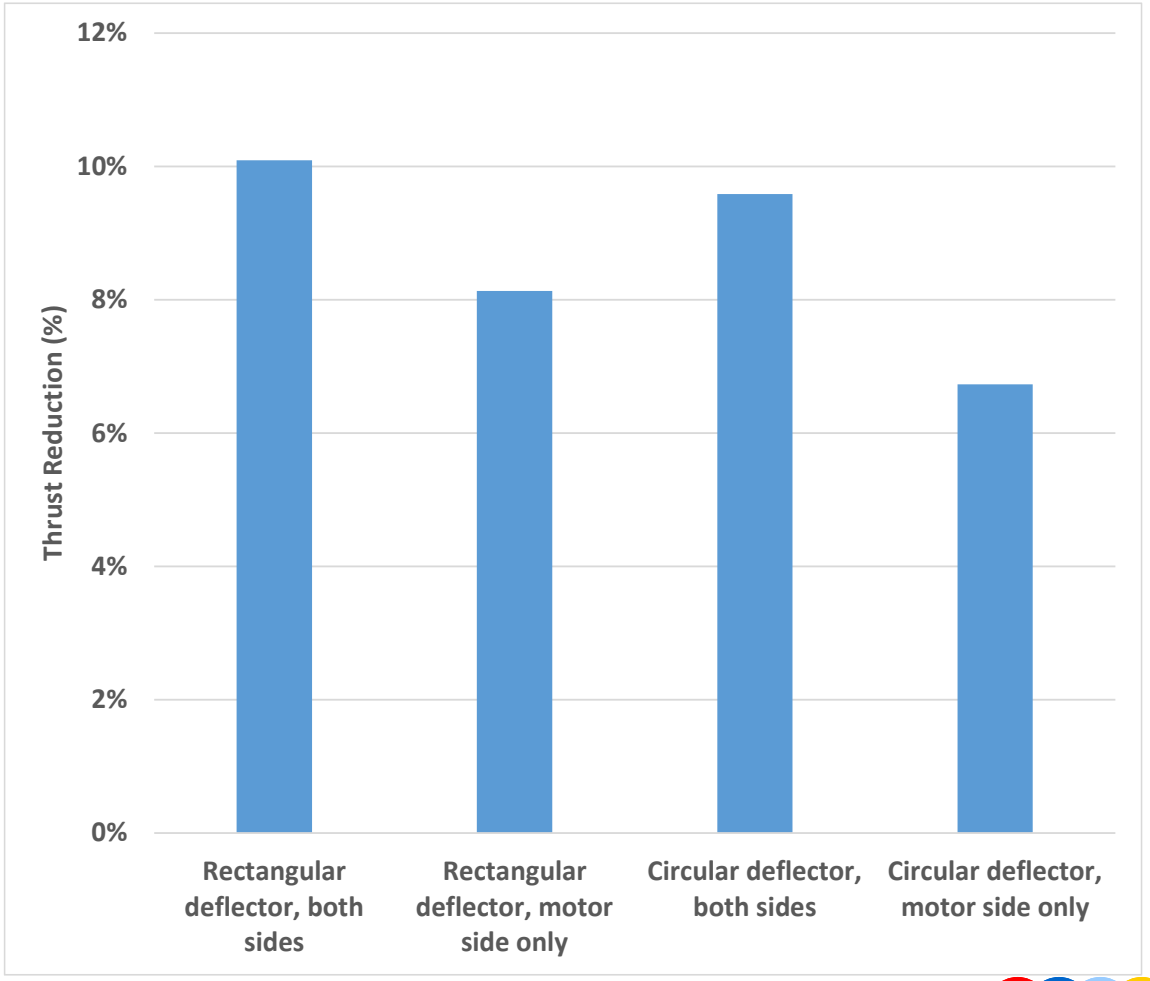
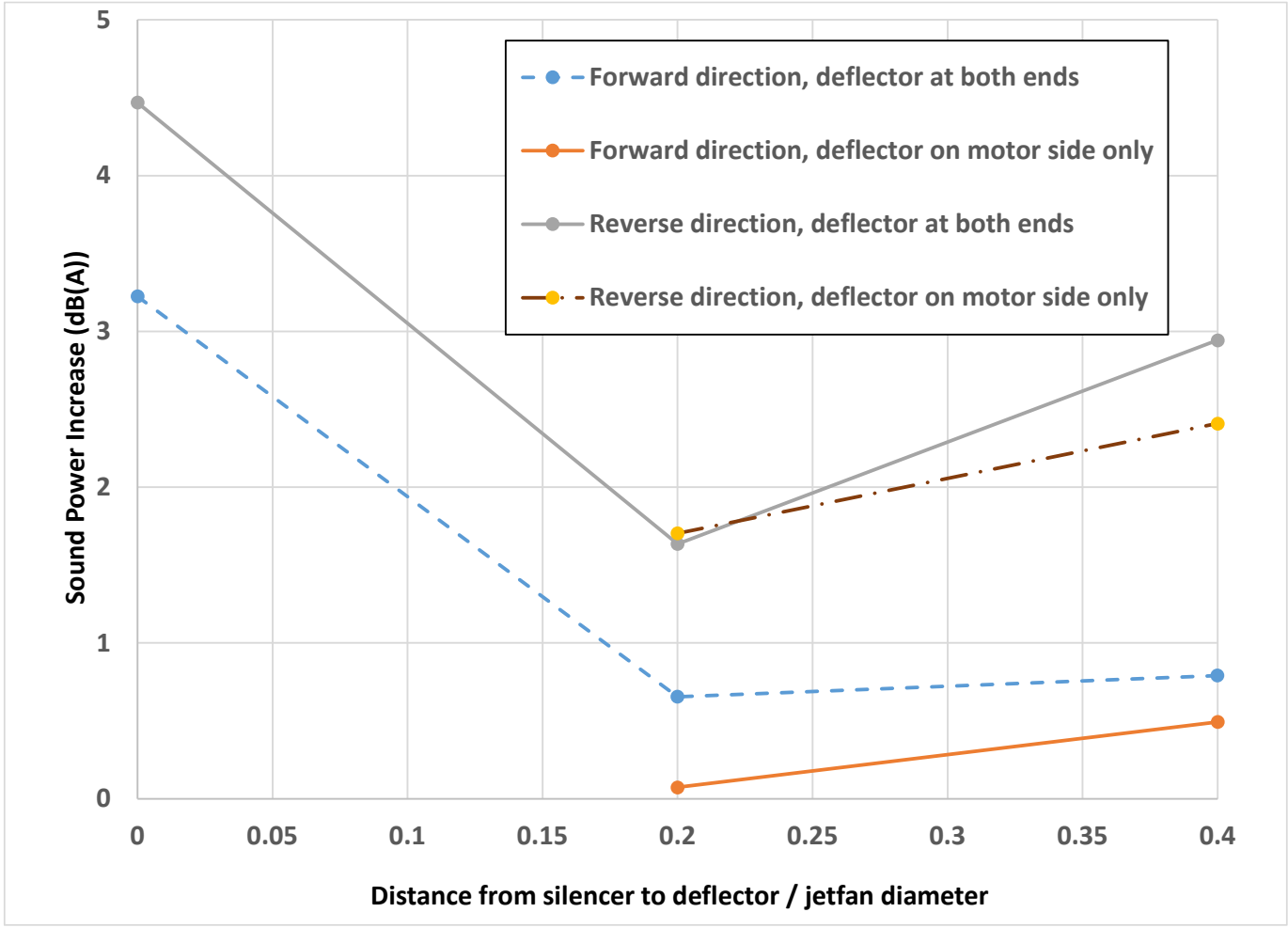
Thrust Effect: Deflector Type & Installation



Regenerated Noise

- Air velocities of typically between 30 to 40 m/s are discharged from the jet fans and strike the vanes.
- Noise regenerated due to: vortex shedding behind the vanes, and mechanical vibrations of the vanes.

Regenerated Noise



Measurements according to ISO 13347-4:2004 "Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 4: Sound intensity method".

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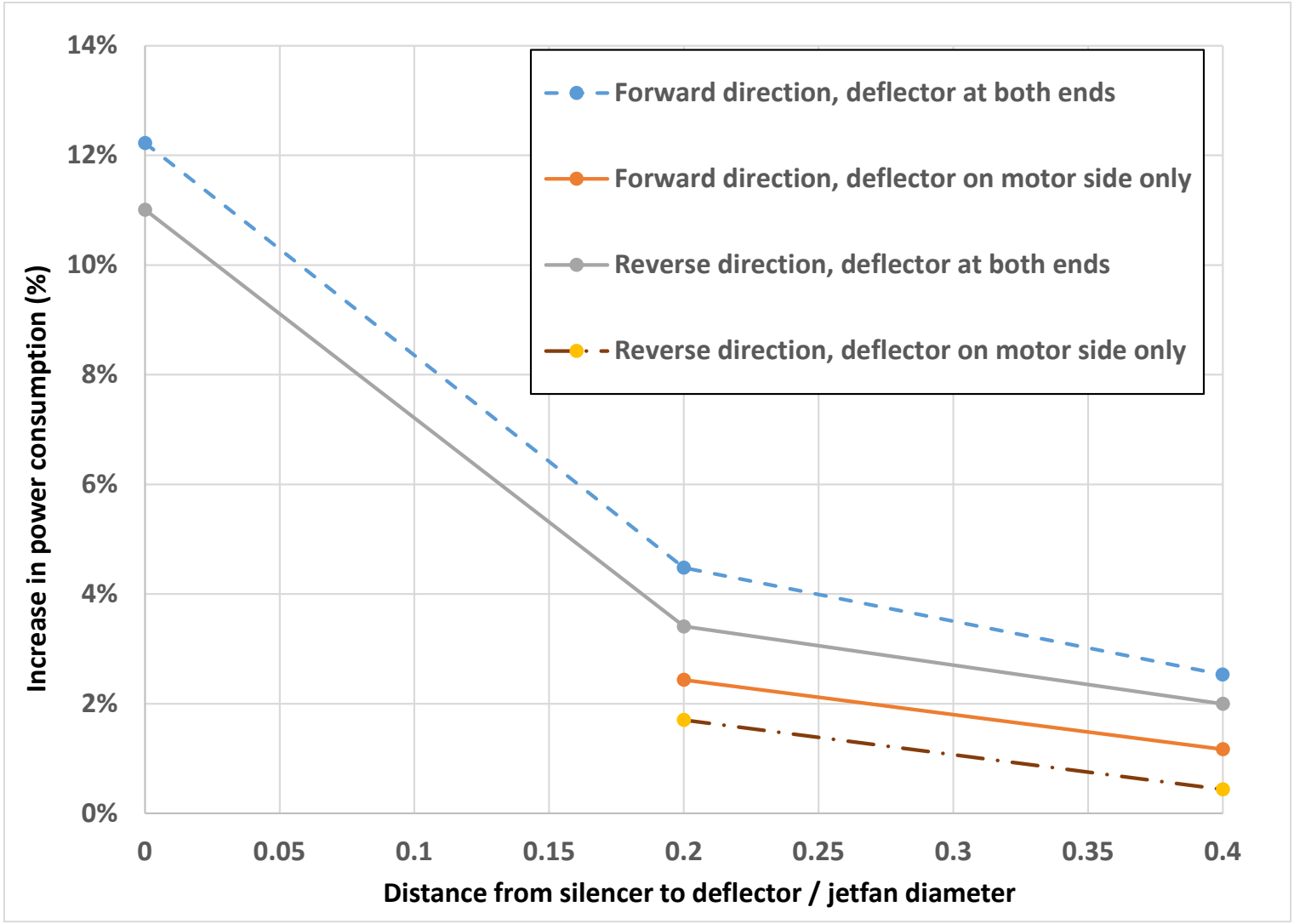
Power Consumption



Measurements in accordance with ISO 13350:2015

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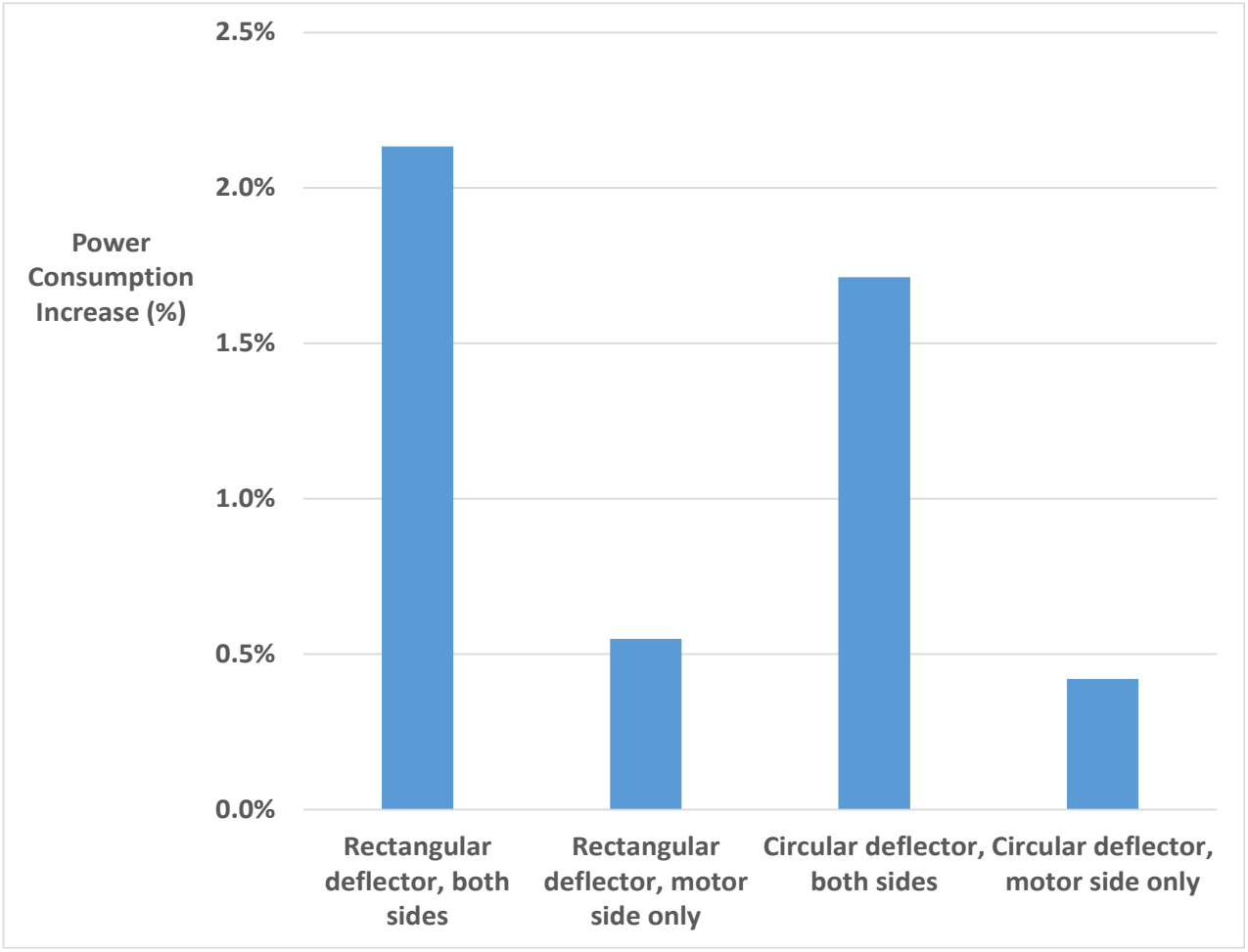
Power: Effect of Deflector Type & Installation



Structural Integrity - 1

- Jet-induced excitation of the vanes causes them to vibrate at their natural frequency and multiples thereof.
- Depending on the natural frequency and the robustness of the fixings, the vanes may be prone to fatigue-induced failure.
- BS 7608:2014+A1:2015 “Guide to fatigue design and assessment of steel products” applies.

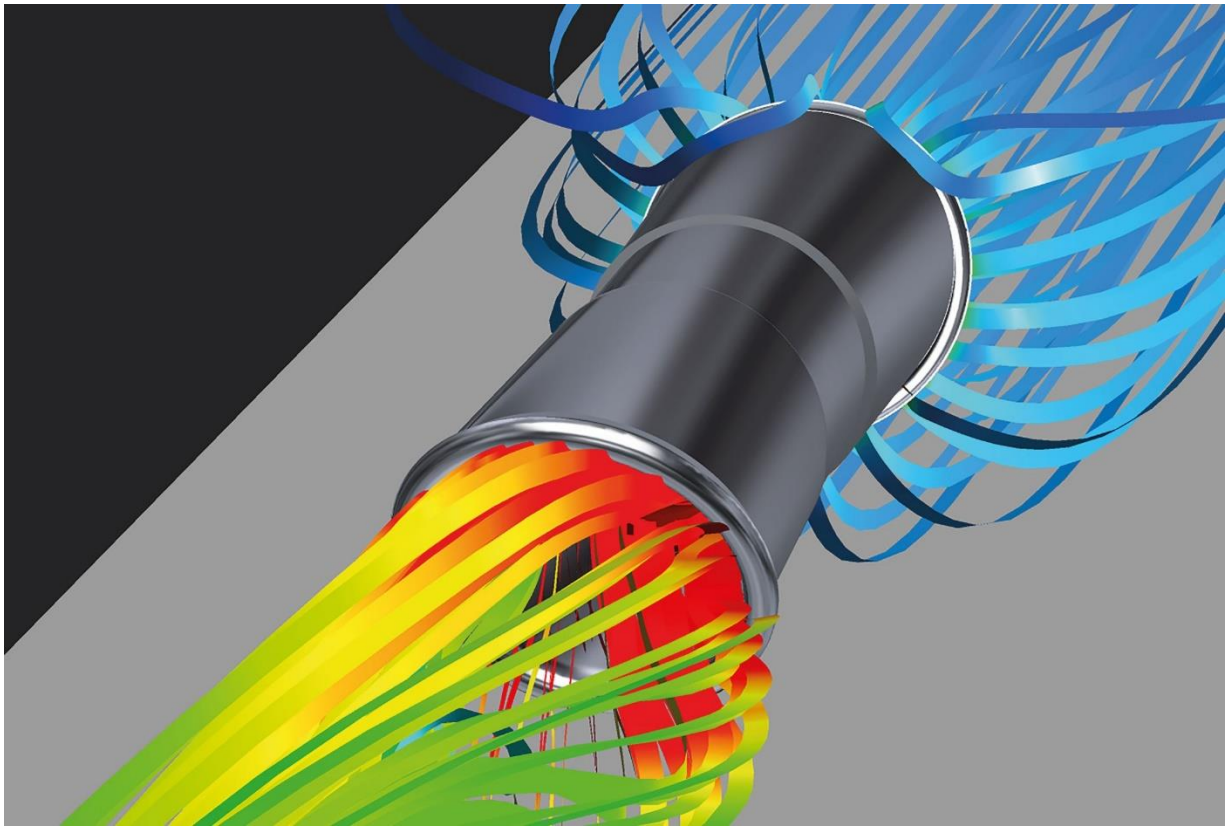
Structural Integrity - 2

- If failures occur, they may potentially cause the vanes to fall onto moving traffic below, and this presents a safety risk.
- Fan manufacturers, installers, consultants and tunnel operators may all be liable for any injuries or deaths, even after the expiry of any warranty periods.

Structural Integrity - 3

- For safety reasons the deflector should have a significantly longer fatigue life than the motor bearing life, e.g. 100,000 operating hours.
- Tunnel inspections (undertaken to the Highways England (2020) CS 452 standard, for example) should prioritise the inspection of deflector vane joints on a risk-assessed basis.

Flow from Jet Fans



Flow discharged from jet fans exhibits a high degree of swirl, which assists in dissipating the jet and imparting its axial momentum

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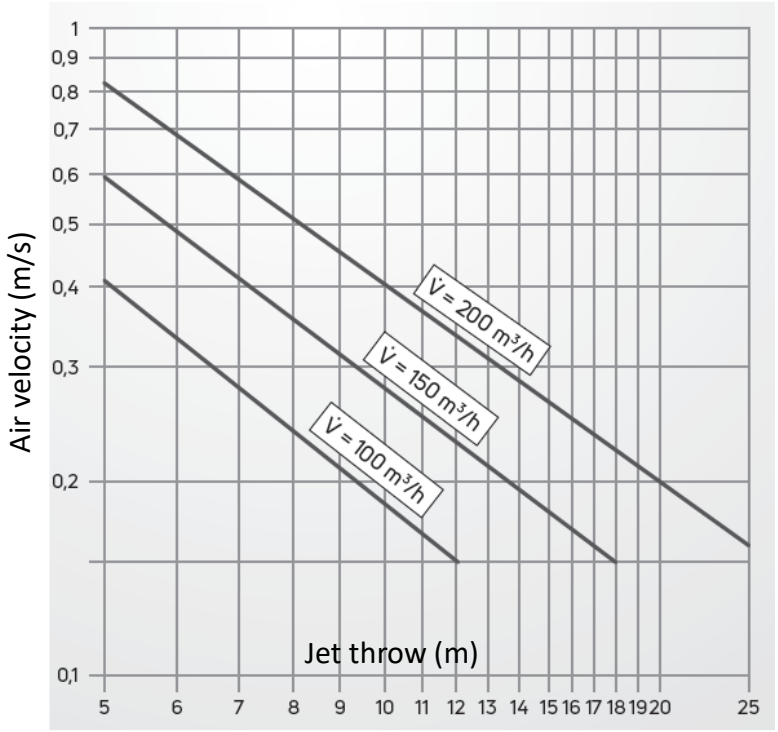
Effect of Deflectors on Throw

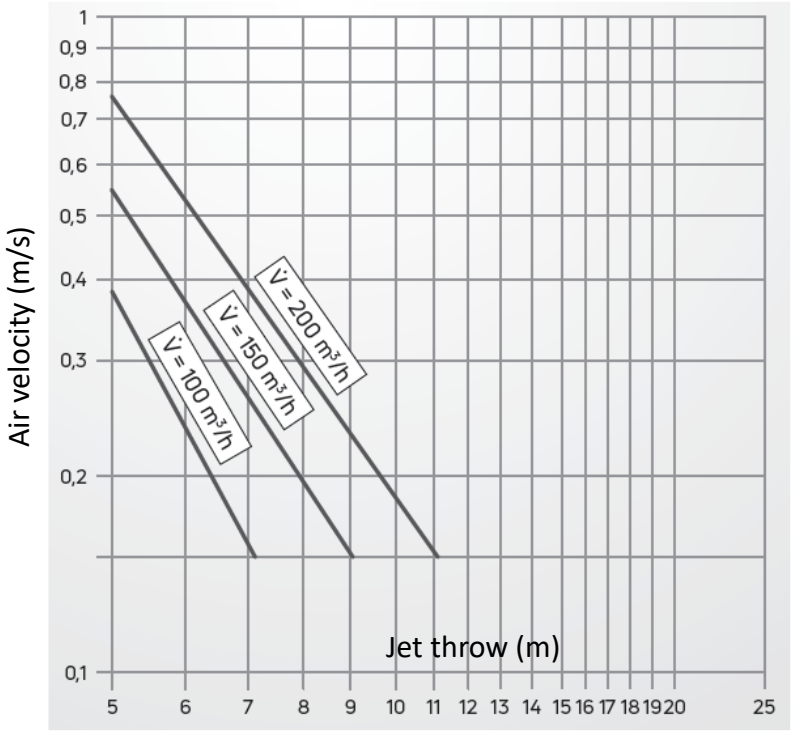
- Deflection vanes tend to kill the swirl and hence significantly extend the jet throw.

Effect of Swirl on Jet Throw (Diffusers)

Without Discharge Swirl



With Discharge Swirl



Jet throw can be extended by more than 100% through the addition of deflectors

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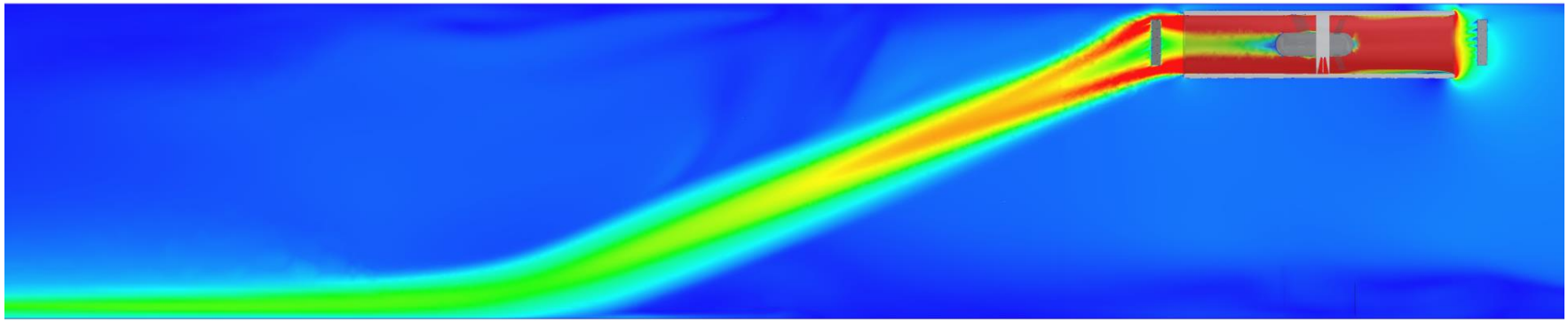
Effect on In-Tunnel Thrust



If the jet attaches to the tunnel floor, a dramatic reduction in in-tunnel thrust can occur (installation factor down from 0.84 for a conventional jet fan to 0.60 for a jet fan with deflectors)

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Effect on Vehicles and Pedestrians

- Heavy goods vehicles and buses may be buffeted due to the extended jet throw.
- This can also lead to a lower effective thrust due to the attachment of the jet to vehicles.
- Pedestrians and emergency responders walking along the tunnel may be subjected to air velocities in excess of the recommended maximum (11 m/s)

Conclusions

- Deflectors potentially provide a significant advantage in improving the in-tunnel thrust delivered by jetfans.
- However, they can also produce penalties in reduced jet fan bench thrust, increased noise production, higher power consumption, risk of structural failure due to fatigue and extended jet throw causing the buffeting of vehicles and pedestrians during use.