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North America

Ducting parameters update and duct-fan system design guidelines for better auxiliary fan selection

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Presentation summary

- Duct-fan system design practice overview
- Review of basic Ventsim duct-fan system simulation parameters
- Shock losses
- Duct-fan system reliability simulations
- Conclusion

Duct-fan system design practice overview

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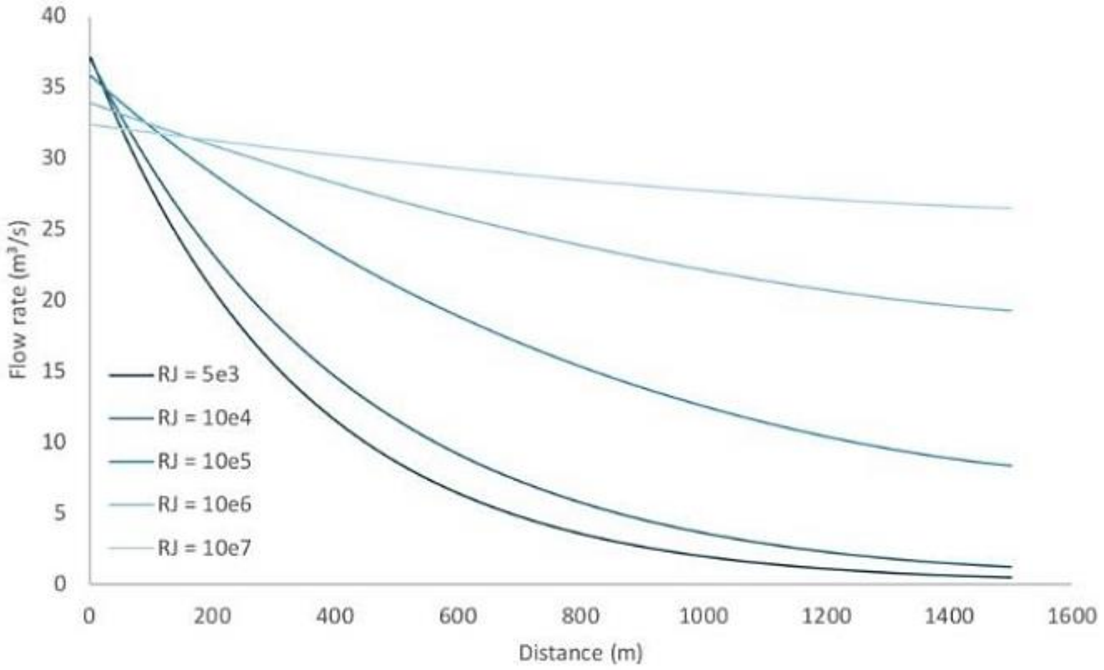
- **On average, duct-fan systems represent 20-25% of an underground mine's total power consumption**
  - Including the fuel consumption of underground mobile equipment, and natural gas/propane for heating in winter-laden countries
- **We tend to rely on rules of thumb to design duct-fan systems**
  - For example, in North America, we like to design systems based on their fan diameter and motor rating, expecting a given face airflow
  - We use presets in Ventsim

Duct-fan system design practice overview

- **Airflow loss rate (percentage) per 100 m inaccurately represents leakage**
  - Leakage is higher in areas of high static pressure and decreases with lower static pressures, i.e., it is higher near the system's inlet
  - The total leakage profile is rarely linear
  - *<u>But the % of losses per 100 m is incompatible with Ventsim!</u>*
- **We tend to omit shock losses**



Airflow profile in a duct-fan system with varying ducting junction leakage

Basic Ventsim duct-fan system simulation parameters

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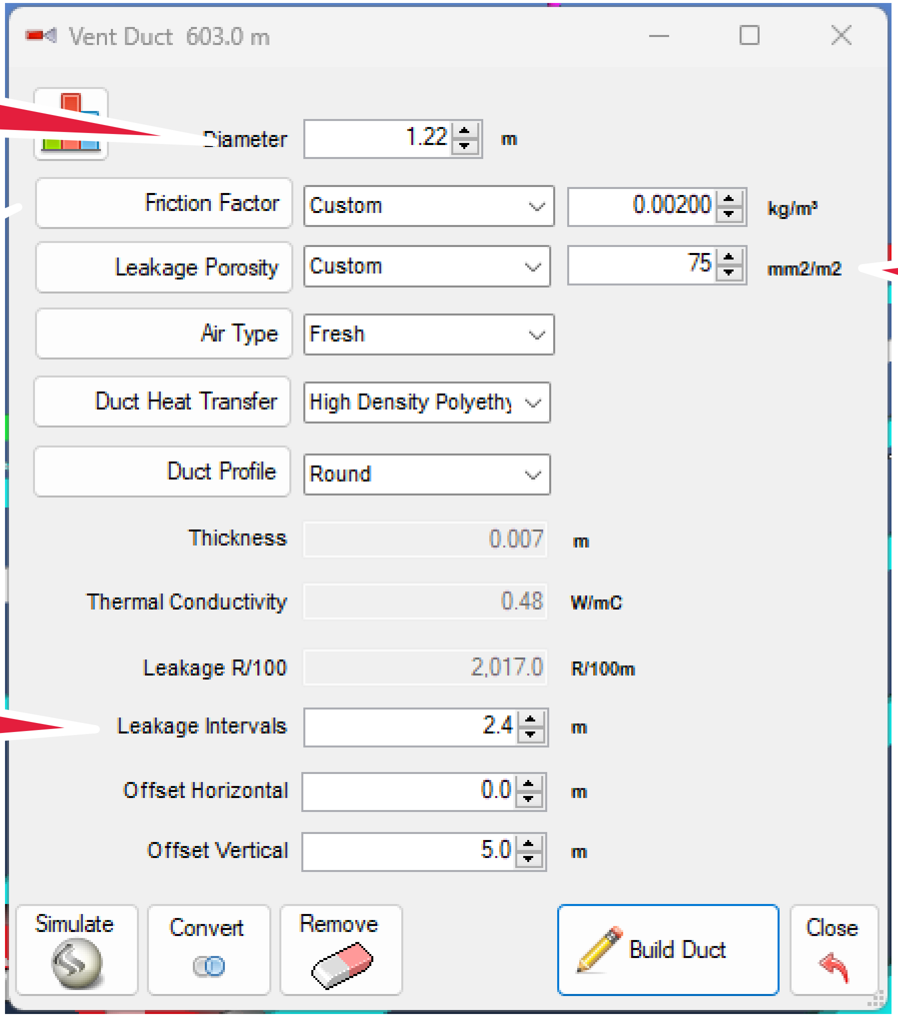
Diameter (ideally the hydraulic diameter)

Friction factor

Leakage intervals (spacing between two ducting junctions)



Leakage porosity (open surface in mm² per m² where air can leak)

Basic Ventsim duct-fan system simulation parameters

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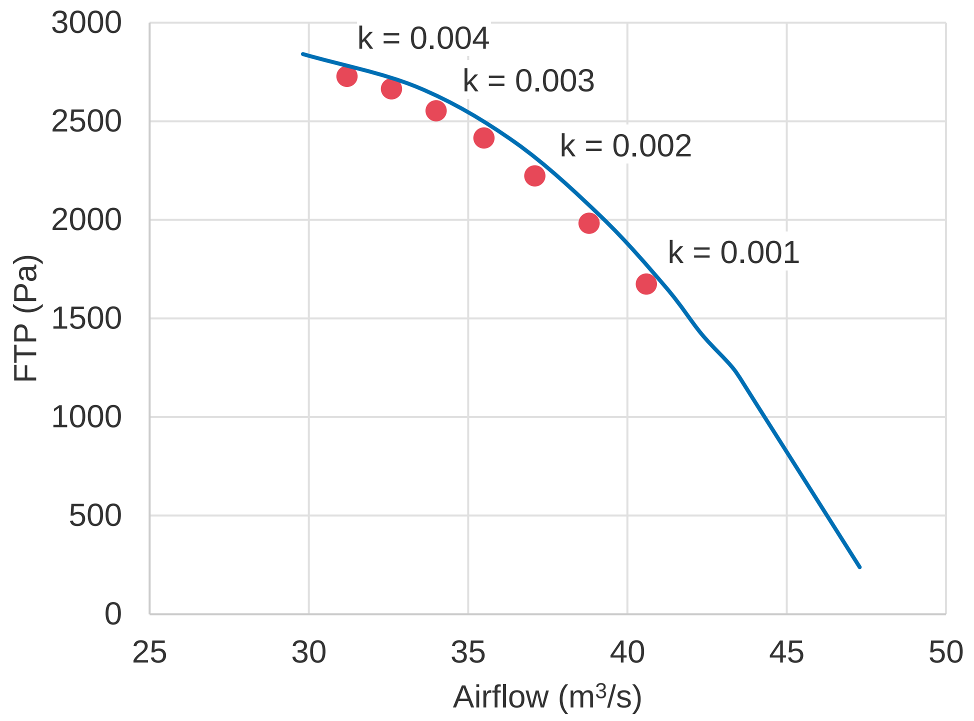
Friction factor

- Confirm friction factor values with peers (or check the table below for guidance)

Ducting type	Typical k factor (kg/m³)
Layflat (vent bag)	0.0037
Spiral	0.0100
Steel	0.0025
Thermoplastic	0.0020



Fan: TLT-Turbo MC1200AP-1S[665H12B-4P60]	
Standard air density	Leakage intervals: 2.5 m
Leakage porosity: 75 mm^2/m^2	Length: 275 m

Basic Ventsim duct-fan system simulation parameters

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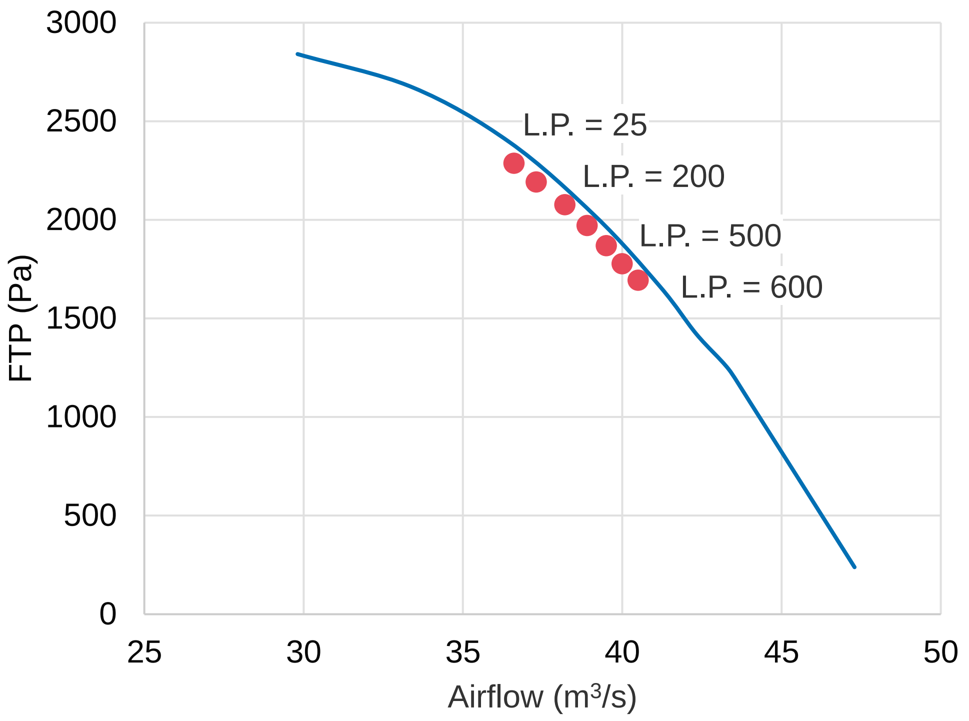
- **Leakage porosity**
  - We can guesstimate leakage porosities by simulating an existing system and achieving the same outlet airflow
  - There is no data reflecting leakage porosity
  - Leakage porosities in Ventsim do not always accurately describe U/G mining installations

Ducting type	Typical leakage porosity (mm²/m²)
Layflat (vent bag)	120 (tentative)
Spiral	?
Steel	?
Thermoplastic	75



Fan: TLT-Turbo MC1200AP-1S[665H12B-4P60]

Standard air density	Leakage intervals: 2.5 m
$k = 0.002\ kg/m^3$	Length: 275 m

Shock losses

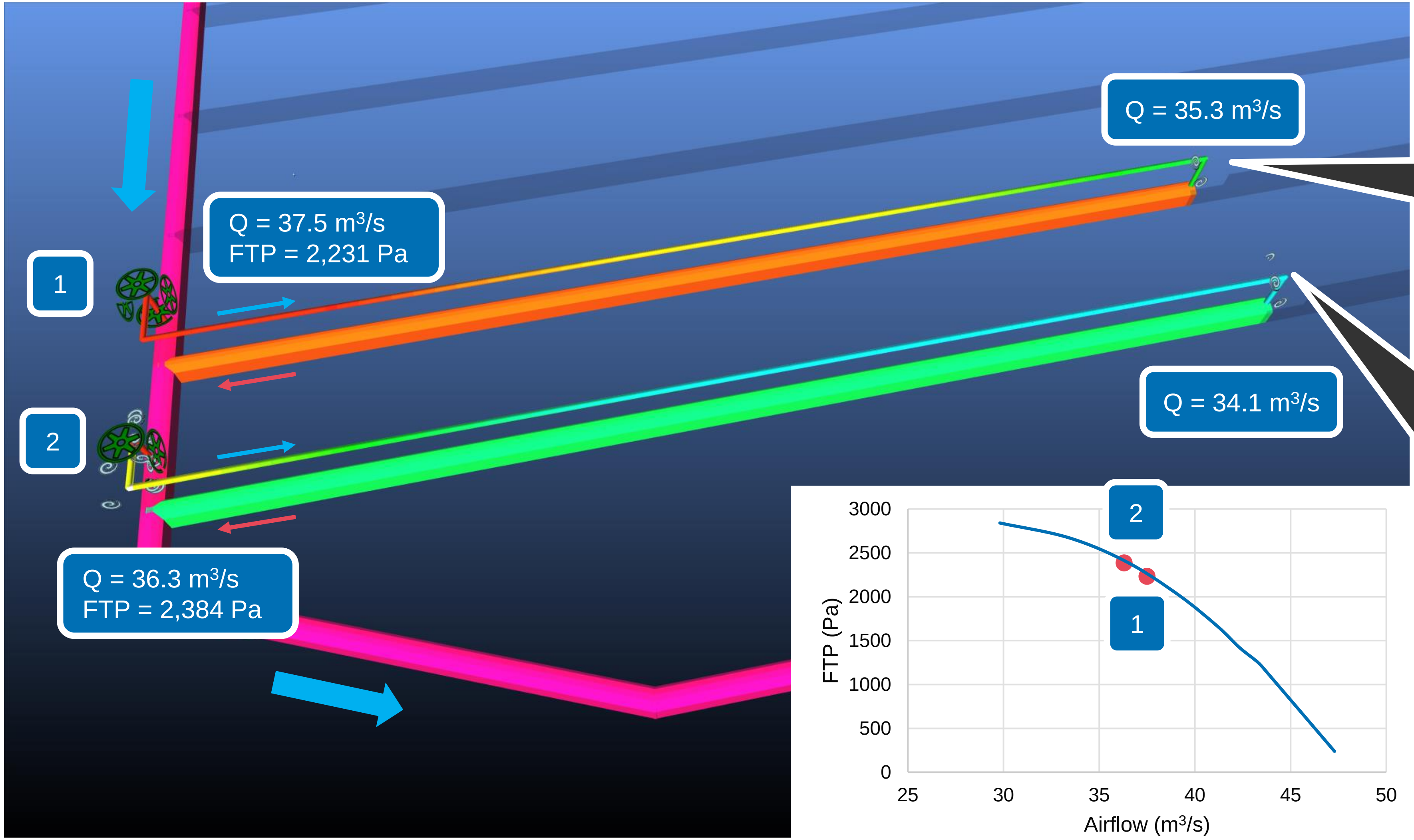
- Shock losses must be added manually (except the exit shock loss)

- $$p_X = X\frac{\rho u^2}{2} = X\rho\frac{Q^2}{A^2} = X\frac{16\rho}{\pi^2}\frac{\boldsymbol{Q^2}}{\boldsymbol{d^4}}$$

- **Air velocities range from 20 m/s to over 30 m/s in duct-fan systems!**

- Generally, the most significant shock losses occur in the first third of the system (and at the system outlet)

Shock losses



Exit shock loss (541 Pa)

Includes shock losses from:

- **Inlet screen and bell** (86 Pa)
- **2 x silencers** (114 Pa)
- **90° bend** (112 Pa)
- **Exit** (507 Pa)

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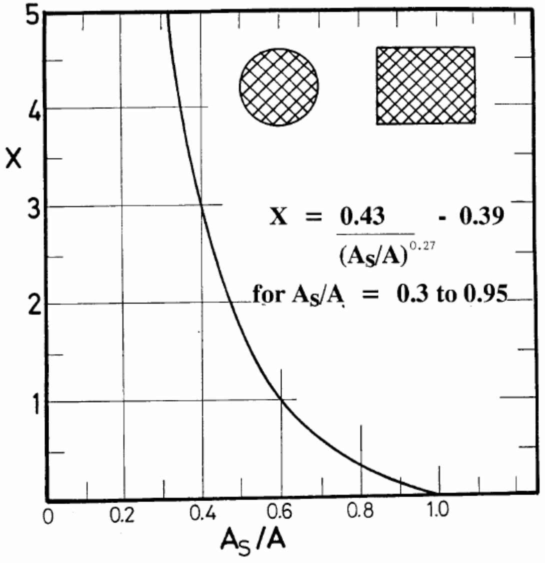
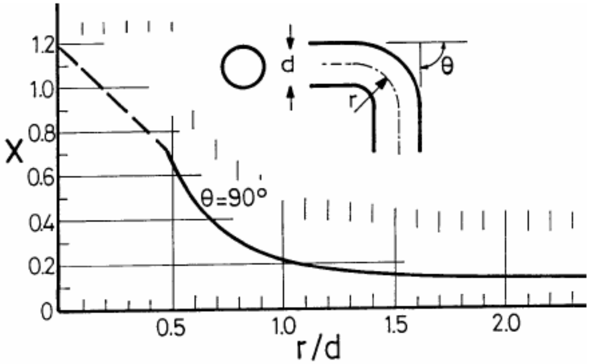
Most common shock losses

Shock loss source	Shock loss factor
Screen	See graph 1
Inlet bell	0.05
Converging transition (45°)	$X = 0.33(1-A_2/A_1)$
Sharp contraction	$X = 0.50(1-A_2/A_1)$
Silencer (full-flow)	0.1
Silencer (podded)	0.75
Evase, diffuser, enlarging transition	0.29* (TLT-Turbo)
Sharp expansion	$X = (A_2/A_1-1)^2$
Bend	See graph 2 & 3
Damper	Variable**
Exit	1

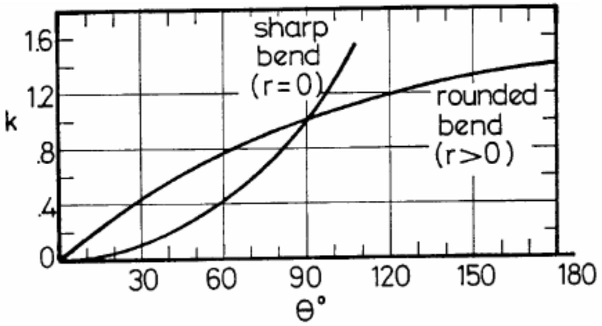
Graph 1 (McPherson)



Graph 2 (McPherson)



Graph 3 (McPherson)



* TLT-Turbo Fan Advisor   ** De Souza (Auxiliary Mine Ventilation Manual)

Duct-fan system reliability simulations

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- Development ventilation frequently relies on long duct-fan systems (600+ m) that can operate for 12-18 months
- Power requirements can exceed 500 kW and reach up to 1 MW
- These duct-fan systems are subjected to damages that influence their reliability
- Damage can increase the total system leakage by up to 5 times
- Friction factor can increase because of ducting damage (kinks, undesirable bends)

Duct-fan system reliability simulations

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Run independent duct-fan system simulations!

- Increase the leakage porosity incrementally by 10% and up to 50%
- Increase the friction factor between 10% and 30%
- Add shock losses in critical areas, not just where they are expected
  - Ducting is particularly vulnerable in crosscuts, especially if it intersects with services
- Verify if the initial fan selection is still suitable or change accordingly
  - Avoid stall conditions
  - Ensure sufficient airflow is delivered to the face
- Confirm that the duct-fan system power requirements are *still* within the mine's capacity

Duct-fan system reliability simulations

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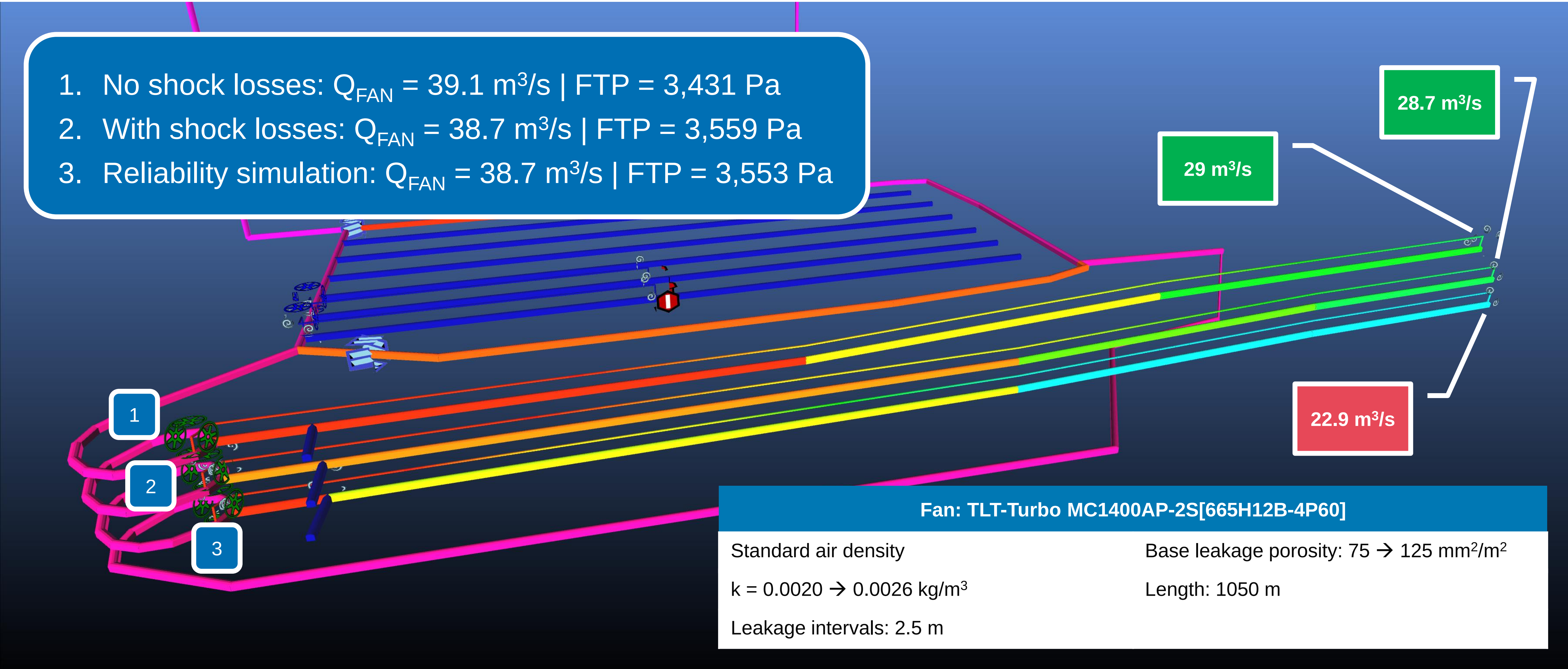
1. No shock losses: Q_{FAN} = 39.1 m³/s | FTP = 3,431 Pa
2. With shock losses: Q_{FAN} = 38.7 m³/s | FTP = 3,559 Pa
3. Reliability simulation: Q_{FAN} = 38.7 m³/s | FTP = 3,553 Pa



Fan: TLT-Turbo MC1400AP-2S[665H12B-4P60]	
Standard air density	Base leakage porosity: 75 → 125 mm²/m²
k = 0.0020 → 0.0026 kg/m³	Length: 1050 m
Leakage intervals: 2.5 m	

Conclusions

Conclusions

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- **Pay attention when performing duct-fan system simulations!**
  - Underestimating leakage parameters impacts and omitting shock losses → more airflow at the face in the simulation than in the operating system
- **The auxiliary fan output and selection depend on the result of the duct-fan system simulations**
  - In the case of an underperforming duct-fan system, we must review operations, or we add fans to the system, increasing its power requirements
- **It is good practice to run reliability simulations, especially for long duct-fan systems**
  - Ensure a proper fan selection to avoid nasty surprises!