Howden
A Chart Industries Company

White paper

Howden Tunnel Ventilation Solutions

Supporting design excellence

Revolving Around You™

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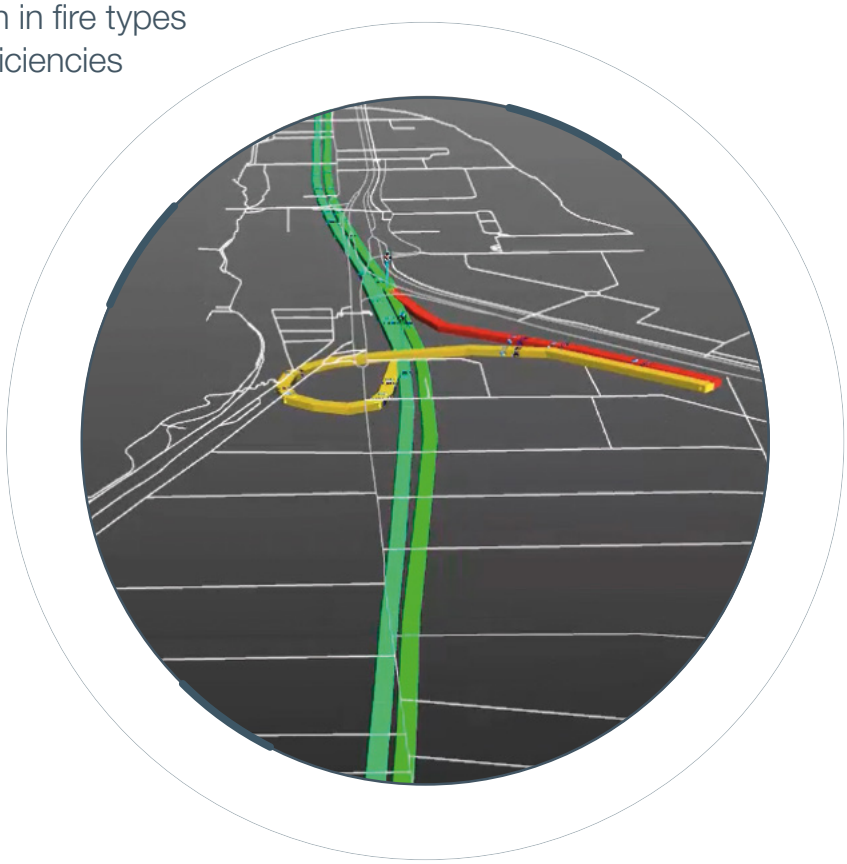
Supporting design excellence

Tunnels can connect remote locations, ease transportation within a congested metropolis and allow large numbers of people to reach their destinations with a collective lower carbon footprint. Their popularity therefore is assured; nevertheless, they remain feats of engineering, requiring design that satisfies a vast array of requirements and regulations.

When it comes to the ventilation system, the practicalities of sufficient air and ability to deal with smoke in cases of fire lead the list of requirements. However, air quality and emission levels, variation in fire types and ongoing operating cost and efficiencies all come into play.



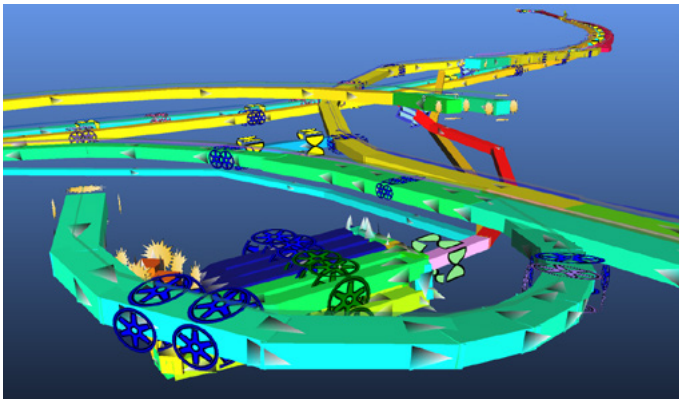
The concept – a good place to start

The ventilation system is the lifeblood of the daily operation of the tunnel, without it there can be no safe use of the space. Its design therefore starts at the beginning as the physical concept of the tunnel takes shape. As tunnel engineers begin to build up a view of the route and structure of the tunnel, so they also need to consider how the ventilation system will map to the tunnel, whether this involves in-tunnel fans or ducting systems served by ventilation stations.

At this point, Howden's Ventsim™ software plays a key role in developing and testing out the system. The software has been developed over 20 years in support of underground ventilation. One of Ventsim's key attributes is the highly visual and user-focused interface. As an enabling tool, Ventsim™ Tunnel DESIGN is focused on delivering functionality in an easy and understandable way for users. The intuitive interface enables the designer to rapidly develop the ventilation concept model and allows more time to then test and improve potential designs.

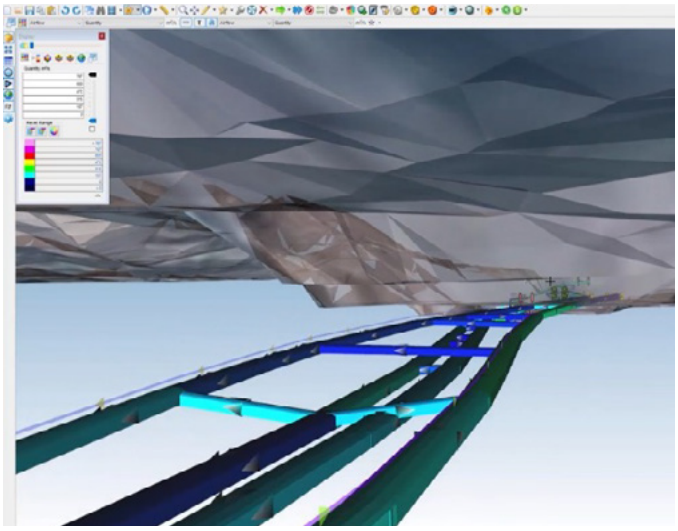
Context is king

As important as the ventilation system is, it is just part of the larger tunnel design and needs to be seen within the context of the whole project. Ventsim models are built in 3D and can integrate with industry standard tools and formats such as CAD and BIM. This enables the designer a familiar entry point to the model and provides a consistent and accurate view of the ventilation system within the overall engineering design.



A picture is worth a thousand words

Collaboration between designer, the broader engineering team and project stakeholders plays a central role in reaching the desired output. As ventilation engineers work with the different technical requirements of the tunnel they can assign different colours to parameters, map flows and overlay text and metrics at key points in the system. All of this provides greater clarity for the designer as well as for information sharing with team members, including those that are less familiar with the design process or the specifics of ventilation. Graphical representation aids the collaboration with everything from the location and timing of gas peaks to topographical views of the ventilation mapped to the tunnel.



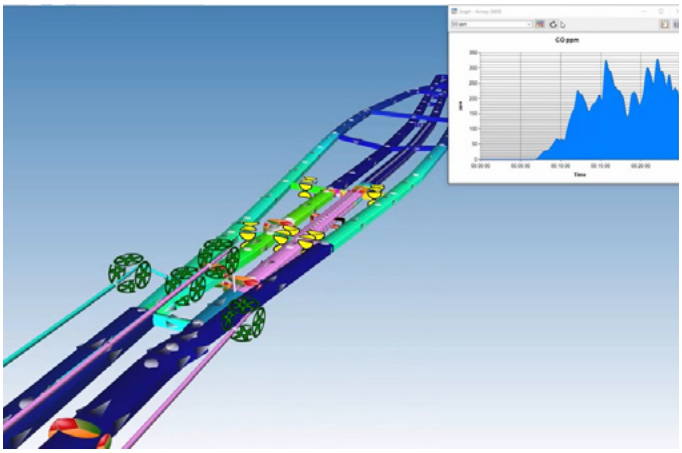
Testing to perfection

There are a multitude of considerations to be included in the system from expected air and gas flows to specific tunnel phenomena such as piston effect and critical velocity.

Once the model is constructed, a wide range of simulations are possible to meet all tunnel operational design requirements. Typical simulations include required air flow, gas levels from Diesel Particulate Matter (DPM), carbon monoxide, nitrogen dioxide and emergency protocols resulting from vehicular fires to name a few.

Simulations provide design engineers with a thorough understanding of behaviours that can be expected when the tunnel is operating normally and in emergency situations. Ventsim Tunnel DESIGN incorporates the PIARC vehicle database, meaning that engineers can measure designs against recognised thresholds based on current and future traffic expectations. The impact of piston effect and back layering on flow can also be easily determined by pre-set calculations. Fan data can be added to an expandable database to enable an understanding of required fan numbers and capacities.

The extensive base of built-in functionality in Ventsim Tunnel DESIGN assists the engineer to reach a final system design that is optimised on the basis of sizing, efficiency, and safety.



Everything has a price

Safety may well be the leading principal guiding the design, but the many options can result in a variation in implementation costs as well as longer term operational costs. Ventsim has built-in cost calculations for financial and performance analysis. Cost models can be updated with real information and data on all ventilation system components. This provides an accurate view of the relative construction costs that can be expected for each ventilation design and performance level.

Expected performance data from fans selected can be used along with projected power usage and pricing to understand annual operational costs. When combining the costing functionality with the design, the engineer and client can make informed decisions and select options to fully satisfy requirements in the most cost effective manner.

Moving from design to implementation

To achieve a design that excels in practice as in principal, careful selection of components is important.
Fans are the critical equipment providing ventilation air and extraction of harmful gases and potentially smoke.

All about the flow

When it comes to air and gas, Howden have been making equipment to process it for over a century in tunnels alone.

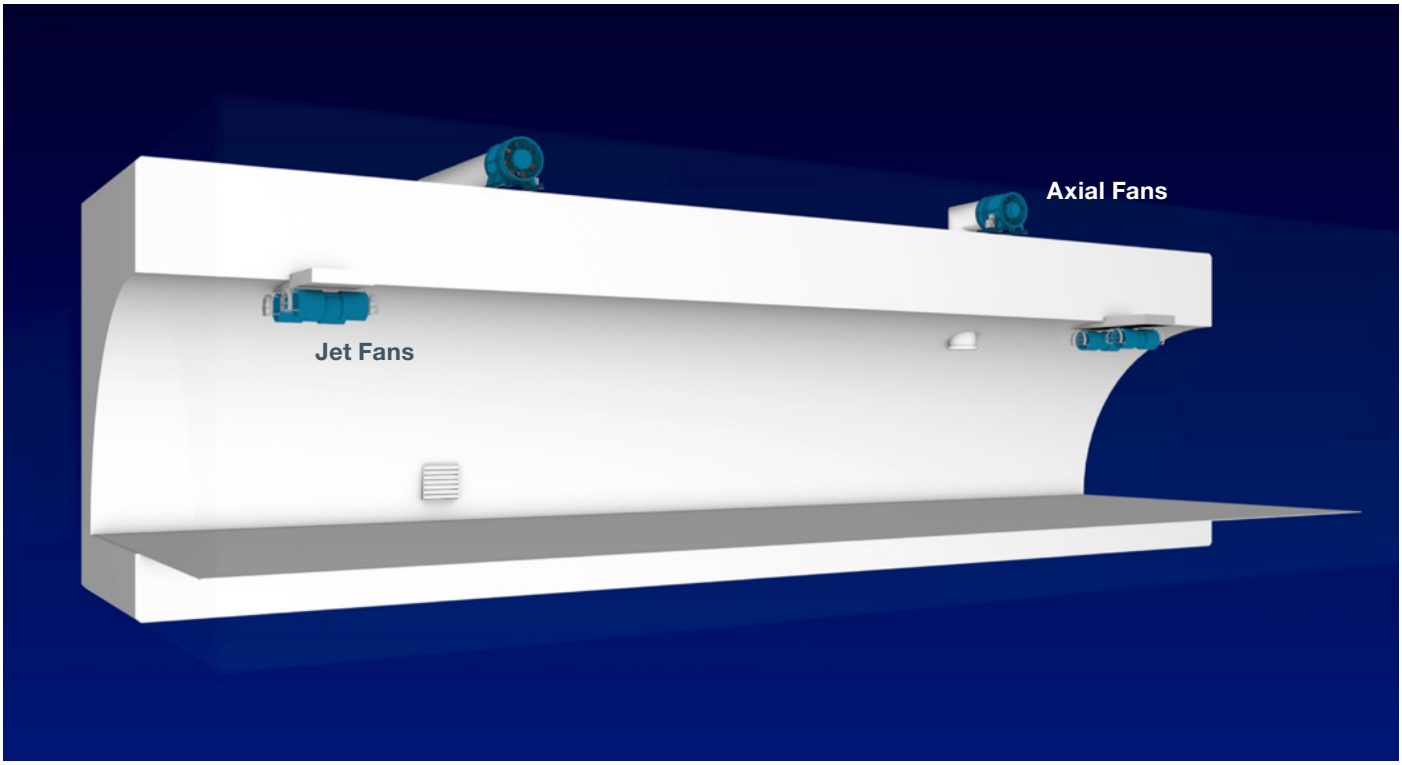
Fans are used to supply fresh air and also in reverse to extract exhaust fumes and potentially smoke. Fan selection will initially depend on whether the tunnel requires transverse or longitudinal ventilation, in some cases a mix of the two. Ultimately, Howden supply fans capable of satisfying both systems.

Axial fans are preferred where large volumes of air are required, and are ideal for tunnel ventilation using transverse or semi-transverse techniques. The fans are placed in stations, connected through ducting to the tunnel and are set to operate uni-directional or fully reversible, where supply and extraction are required.

In volume terms, Howden fans have one of the widest ranges on the market. Flows of up to 400m^3/s are possible using the UMAF axial fan range.

This is suitable for the majority of infrastructure tunnels, but as a supplier to multiple industries requiring very high volumes, Howden have other fan series that exceed this capacity. Pressure rises of up to 4000Pa address most tunnel lengths, but significantly higher pressures can be catered for if required, potentially using 2-stage configurations.

For longitudinal tunnels, jet fans are more commonly used. These fans are mounted within the tunnel and propel external air along the length. In this case, thrust is the key metric. Howden's AP and AQ series can deliver up to 3360N of thrust to meet required air quality and extract smoke during emergencies.



Safe in the knowledge

As a primary concern is protecting tunnel users in the event of a fire, all fan ranges have been performance tested. This involves a series of tests at accredited facilities to meet the most stringent of safety standards (EN 12101-3, NFPA 130/502 or ISO 27927). Fans are exposed to fire conditions with temperatures reaching up to 400°C. They must continue to operate at 200ºC for one hour or up to 400ºC for two hours.

Staying in control

Tunnel conditions can change, meaning that having the flexibility to respond is a real advantage for operators. This is delivered within the design of the fan package either through the variable positioning of the blades or type of drive. Flow control enablement by blade adjustment can be achieved for axial fans either at standstill or during operation depending on model selected. Using a Variable Speed Drive (VSD) also gives the ability to dynamically adjust flow and this applies to axial fans and jet fans.

Efficiency: responsible operations with a cost incentive

Efficiency has always been an important target for Howden's engineers, driven by the need to provide customers with the best long-term performance and the lowest operational cost. Now, it combines with the commitment shared by customers to minimise consumption within the context of environmental protection.

Total efficiency is a function of the various components of the ventilation solution. This incorporates the fan itself and the motor used to drive it. Howden aims to be best in class on efficiency and in fact, Howden designs are beyond the EU Ecodesign requirements. Howden supplies fans with IE3 motors and are ready to provide IE4 as demanded.

Customer expectations have increased over the years with 65-70% efficiency once accepted, but 75% in forward flow (uni-directional) and 70% in reverse now the norm. Howden engineers fans to achieve market leading efficiency. The axial fan range is capable of up to 90% efficiency when configured for uni-directional flow and 80% when configured as a reversible fan.

Efficiency gains translate directly to lower power consumption and therefore also into operational cost savings. Clearly, lifetime running hours will vary between those for a fan used continuously for fresh air and those that are purely for emergency use.

Example: medium-sized axial fan with a flow of 150 m³/s and pressure increase of 1200 Pa				
Configuration	**Efficiency (Specified)**	**Efficiency (Howden)**	**Savings per 1000 operating hours (€)***	**Lifetime savings per fan (€)****
Uni-directional	75%	90%	€ 5,263	€ 105,263
Reversible	70%	80%	€ 4,229	€ 84,586

*15 kWh per operating hour and €0.125 per kWh **20 years @1k hours p.a.

About Howden

Howden has a global reach, able to respond in region to the tunnel design community's need for expertise in best-in-class ventilation systems.

Howden's design expertise has been proven from thousands of tunnel fan installations over almost a century of tunnel industry involvement. Continuous development from a focused Research and Development centre brings the latest fan enhancements, while regional manufacturing and assembly provide the basis for swift and economic supply.

Scope of supply is flexible to the needs of customers, ranging from the provision of fans to a full turnkey system including silencers, dampers, ducting and more.

From initial enquiries to technical specifications, Howden supports tunnel ventilation engineers as they strive for excellence on behalf of their clients. Let Howden deliver you industry-leading performance you can rely on.

For more information visit www.howden.com

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