

Variable Pitch Fans Evolution Proofing Underground Works

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Summary

- The Fréjus road tunnel
- The origins of pressure variations
- The variable pitch fans in operation
- The high temperature test EN 12101-3
- The fans in Fréjus road tunnel



The Fréjus road tunnel

- One of the main road crossing points in the Northern Alps in France
 - Altitude 1 200 – 1 300 m
 - Length 12,868 m
- Traffic area
 - Single bidirectional tube
 - Two lanes width 3.55 m
 - Tucks max. height 4.30 m



A transverse ventilation system

- In operating conditions:
 - injecting fresh air and/or
 - extracting stale air at regular intervals
- In the event of a fire:
 - helping for containing the smoke
 - extracting it from the ceiling



Two ducts above circulation space

- Stale air or smoke:
 - 100 smoke dampers
 - every 130 meters
 - in the ceiling of the tunnel
 - Capacity of 1 250 m³/s
- Fresh air:
 - 2 860 air outlets
 - every 4.5 meters
 - bottom of the wall
 - Capacity of 1 500 m³ / s



Six ventilation plants

- The single ventilation plants A & D:
 - head of the tunnel, French side
 - head of the tunnel, Italy side
 - 2 supply fans
 - 2 exhaust fans
 - The double ventilation plants B & C:
 - Km 4.2
 - Km 8.8
 - 2x 2 supply fans
 - 2x 2 exhaust fans
- 24 fans

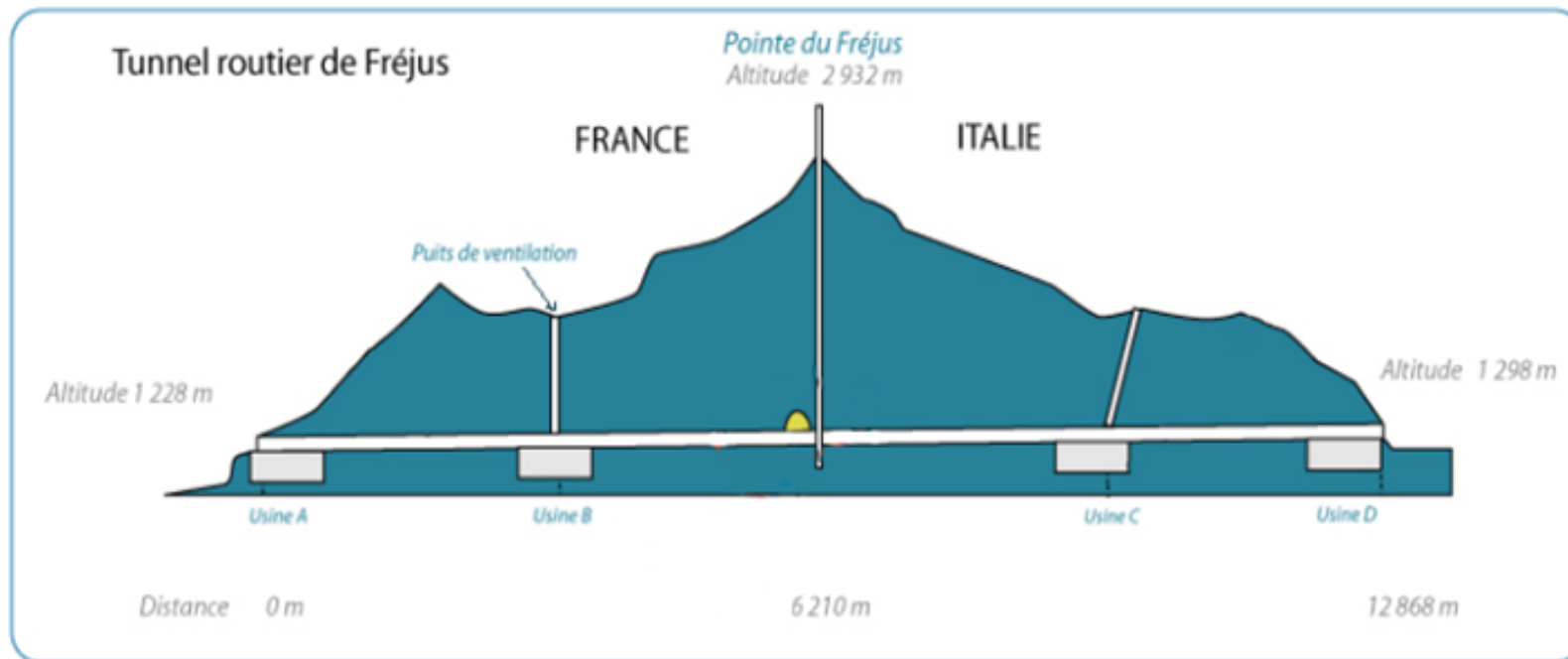


Two vertical ventilation shaft

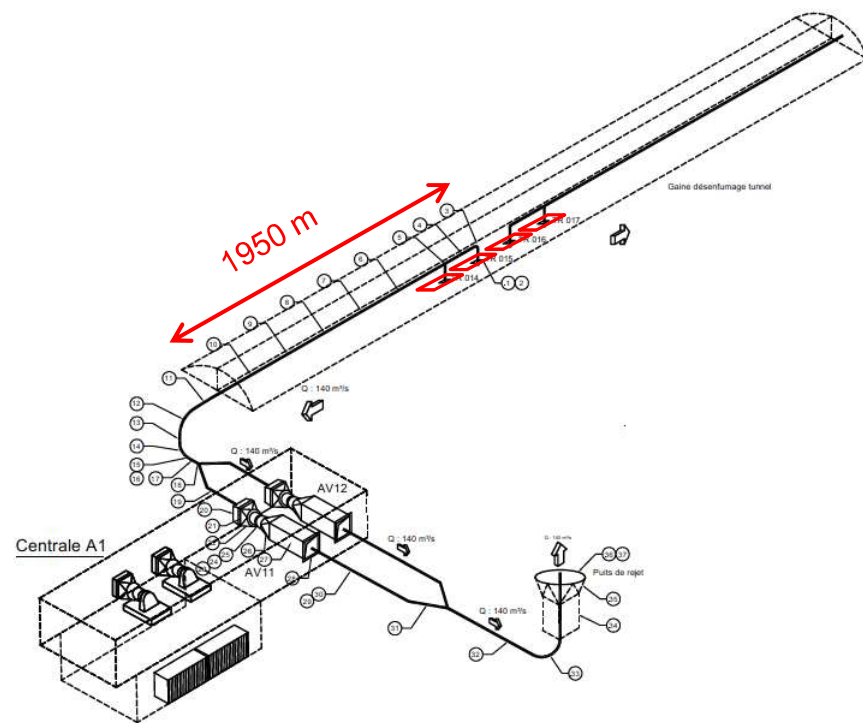
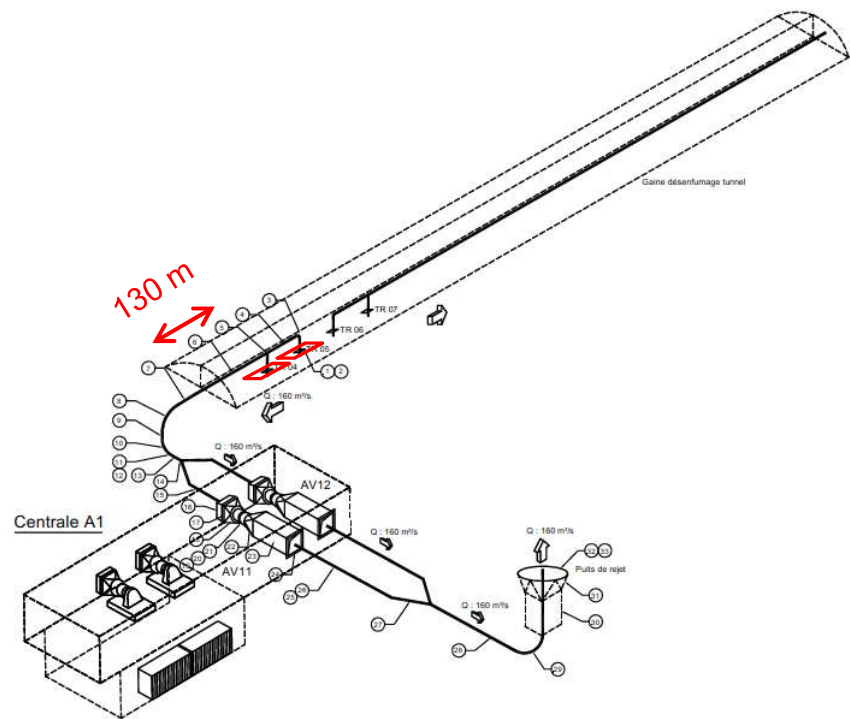
- Ventilation plants B and C supplied by ventilation shafts:
 - approximately 700 m
 - France side
 - Italy side
- Those shafts are also used for the evacuation of stale air:
 - Double ducts



A complex transverse ventilation system



A complex transverse ventilation system



The origins of pressure variation

- To reach the air flow rate in the tunnel, the fans must be designed for the pressure losses in the circuit
- Regular pressure loss
 - Ducts of 2000 m between plant and tunnel
 - Ventilation shaft of 700 m to plant
- Singular pressure loss
 - Transition from plants to ducts
 - Distribution via vents
- Pressure differences between the tunnel and the exterior



The origins of pressure variation

- Variation due to operation:
 - Necessity of fresh air
 - Location of smoke extraction
- Variation due to evolution in climatic pressure:
 - Over the seasons
 - Between day and night
- Variation due to blockage and piston effect caused by vehicle traffic:
 - Blockage effect with 2 front trucks
 - Piston effect with move of vehicles
 - Boost of pressure effect alternatively in one or other direction



The variable pitch fans in operation

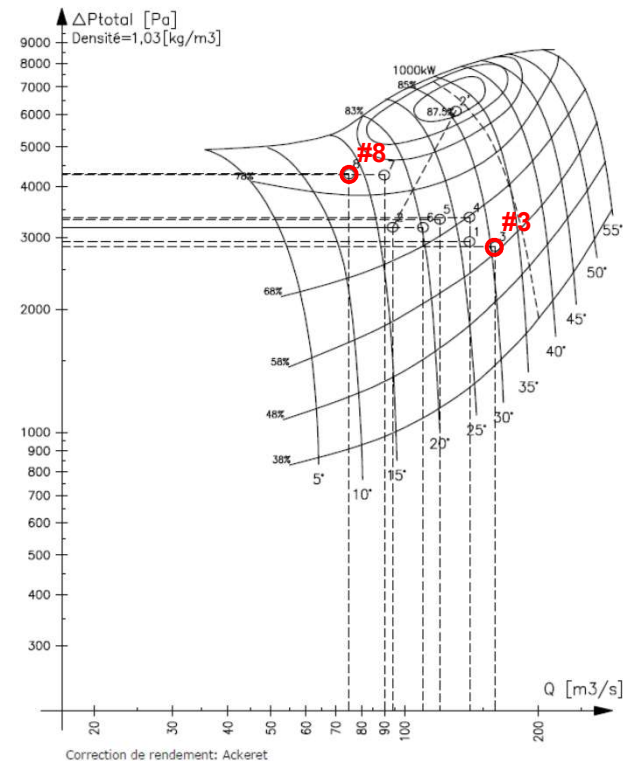
- To cope with the pressure variations in the Fréjus tunnel, it was necessary to consider fans capable of adapting their operating point (flow/pressure)
 - A variable-blade fans in operation
- The principles:
 - Angle of the blades increases
 - Volume flowrate will also increase
 - Pressure constant
- The results:
 - Optimized operating points for all the configurations
 - Expected performance, despite the pressure changes in the ventilation networks



The variable pitch fans in operation in Fréjus

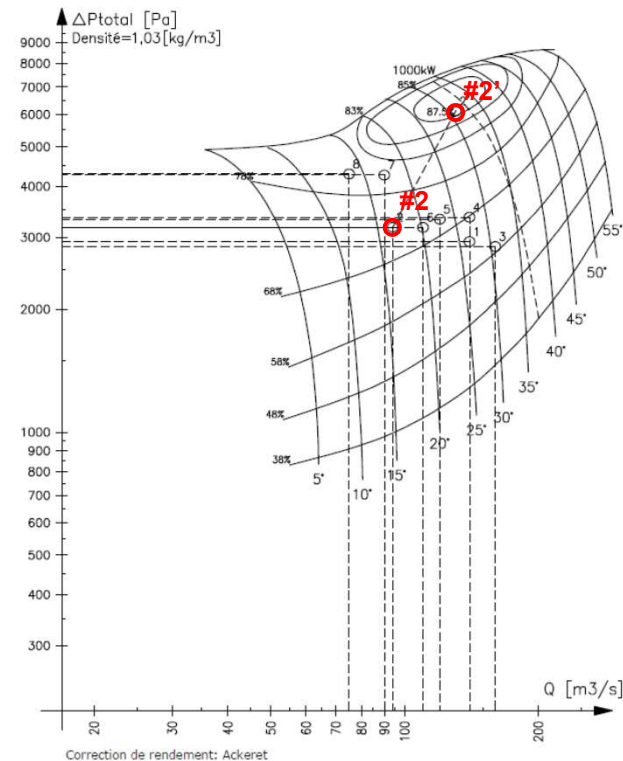
- Working point 3:
 - 160 m³/s - 2848 Pa
 - Exhaust point close to fan plant
 - Low circuit resistance
 - Max efficiency at angle 31°

- Working point 8:
 - 75 m³/s - 4289 Pa (paralell)
 - Degraded mode
 - Exhaust point 4 km from fan plant
 - High circuit resistance
 - Very close to stall at angle 31°



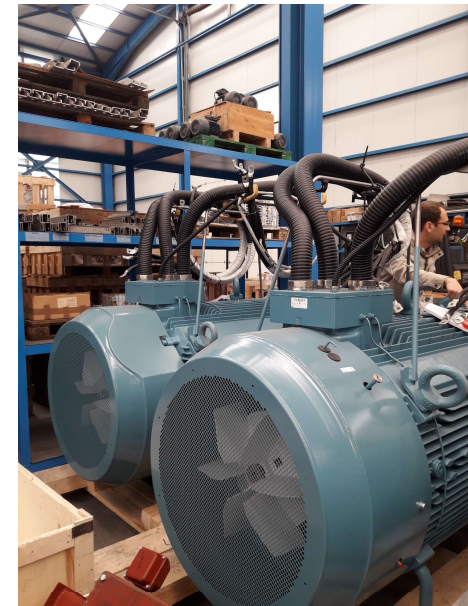
The variable pitch fans in operation in Fréjus

- Influence of frequency converter
- Working point 2:
 - 94 m³/s - 3176 Pa (parallel)
 - Nominal speed:
 - Angle 16°
 - Efficiency 72,0%
 - Reduced speed:
 - Angle 32°
 - Efficiency 87,5%



The variable pitch fans in operation in Fréjus

- Fan characteristics:
 - Impeller diameter: 2 123 mm
 - Hub diameter: 670 mm
 - Number of blades: 20
 - Total mass: 15 T
 - Temperature resistance: 400 °C / 2 hours
- Motor characteristics:
 - Nominal power: 1000 kW
 - Nominal speed: 1490 rpm
 - Mass: 4,900 kg
 - Temperature resistance: 400 °C / 2 hours



The high temperature test

- First time in the World:
 - Power 1 MW
 - Fire resistance F400
 - Variable blade in operation
- When: May 2018
- Who: Zitron
- Where: “San Pedro de Anes” Test Centre, located in Spain

- Standard NF EN 12 101-3 « Smoke and heat control system – Part 3: Specifications for powered smoke and heat control fans » (2015)



The high temperature test



The fans in the tunnel

- Work on site from 2019 to 2021



The fans in the tunnel today

- Ventilation plant A
 - Done
- Ventilation plant B
 - Done
- Ventilation plant C
 - On progress
- Ventilation plant D
 - Civil work on progress



The pros and cons

- The advantages:
 - Between min and max angle: large range of air flow and pressure
 - Speed variator: larger range with +/- 30%
 - Lonely fan or parallel fan
- The inconvenients:
 - Installation: more time
 - Maintenance: more complex



Conclusion

This new machine:

- Developed and manufactured by Zitron
- Tested to high temperature
- Installed by Eiffage

Is a technology adapted to the Fréjus road tunnel location and exploitation

This is also well adapted to changes of operation:

- Unidirectionnal now
- Bidirectionnal soon



Thank you for your attention!



We would particularly thank:

- the Contracting Authority of the Fréjus tunnel (SFTRF)
- the operator (GEF)



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