The Mine Ventilation Society of South Africa Annual Conference 2017

Fire Engineering: A holistic approach to conveyor fire risk management

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The consequence

Two tragic events remain fresh in our minds:

- ❑ 2016 – 4 mine workers tragically lose their lives
- ❑ 2004 – 9 mine workers tragically lose their lives

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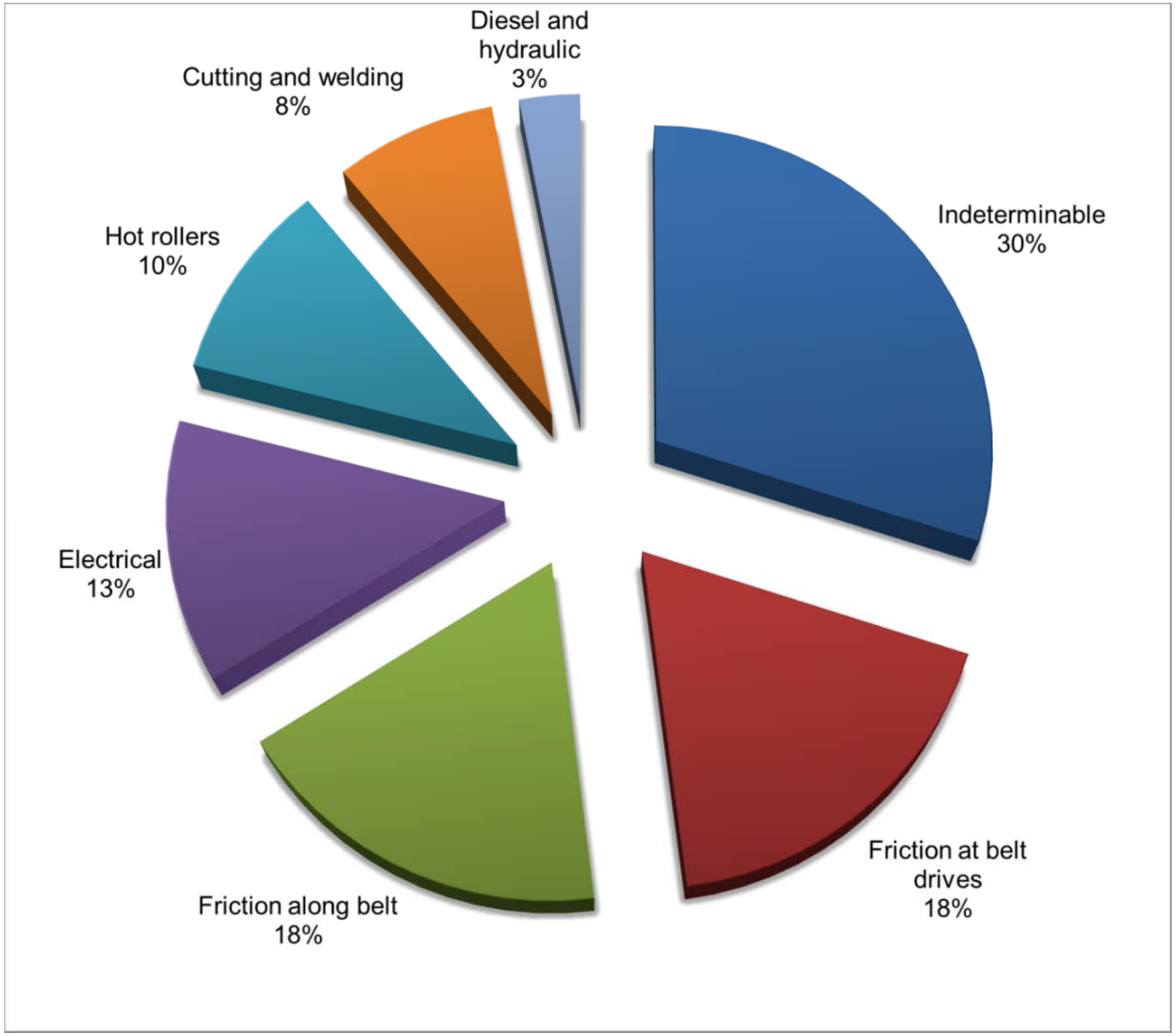
The concern

Total of 27 conveyor belt fires reported to the DMR between 2014 and 2016 (Huma, personal communication)

Certainly an alarming frequency rate considering the possible catastrophic consequences

The causes



MSHA (USA) reports show ignition sources reported for 61 conveyor belt fires during 1980 to 2005 (Frankart, 2006)

The risk

Gases produced during a conveyor fire can include:

- ❑ Carbon Monoxide (CO)
- ❑ Carbon Dioxide (CO_2)
- ❑ Nitric Oxide (NOx)
- ❑ Hydrogen Chloride (HCL)
- ❑ Hydrogen Cyanide (HCN)

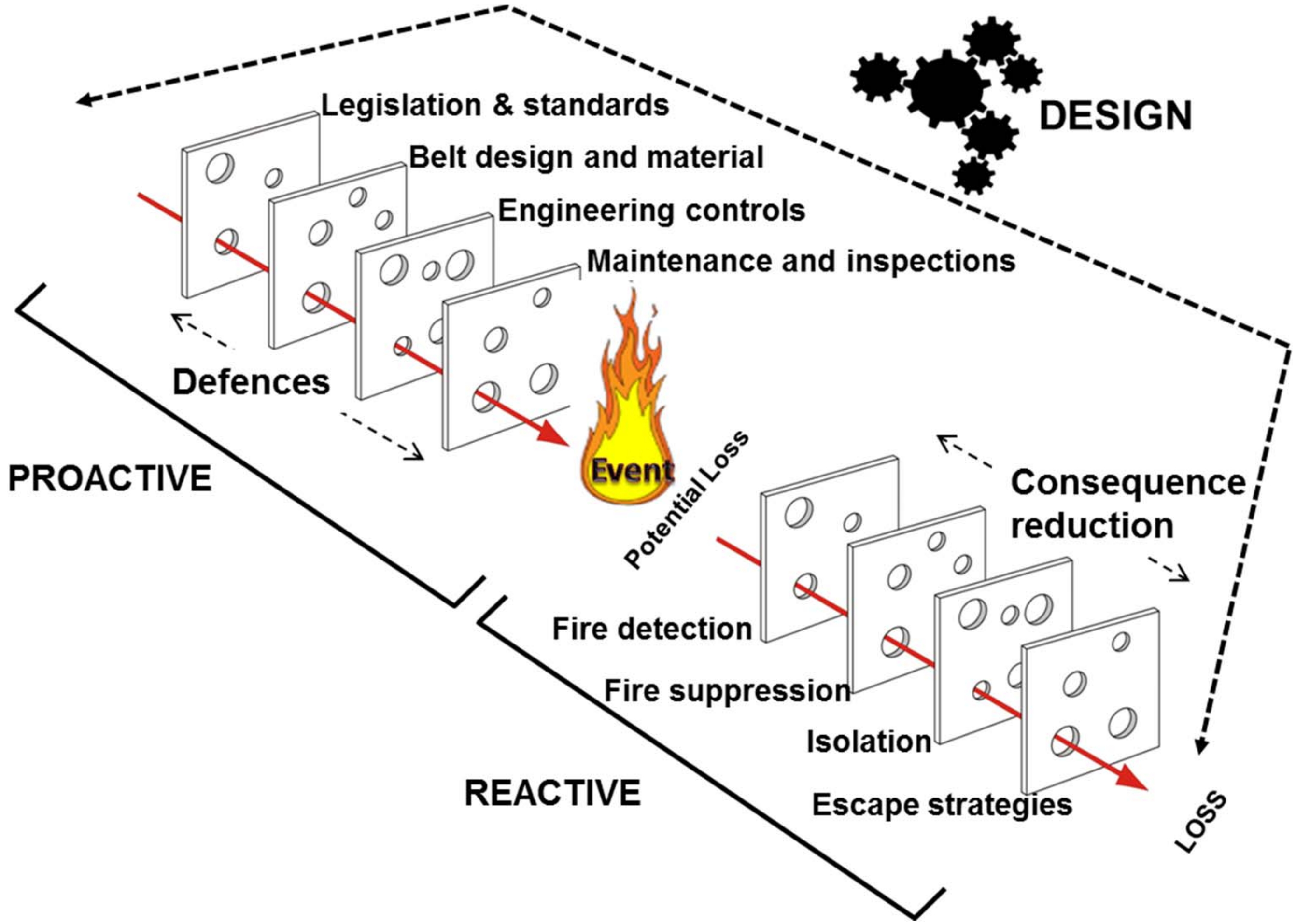
Thick smoke that can hamper escape

High temperatures close to the fire can exceed 1000°C depending on the fire intensity, can cause the belt to flash over and results in high flame spread rate and numerous secondary fires

What to consider

- The Mine Health and Safety act & regulations
- The Mandatory Codes of Practice (CoP):
  - for the prevention of fires in mines
  - for the safe use of conveyor belt installations
- Standards (SANS and NFPA)
- Insurance industry standards (FM Global)
- Mine standards

Reducing the risk



"Swiss Cheese Model" Reason, J. (1990)

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Reducing the risk

Pro-active controls (focus on preventing fire)

- ❑ Mechanical design and materials
  - Design to prevent friction between belt and structure
  - Fire retardant belt as per SANS 971:2013, Edition 4
  - Idlers (rollers) - Steel or HDPE
  - Belt safety devises such as belt slip detection devices, belt alignment devices and bearing temperature sensors.
- ❑ Inspection and maintenance programs
  - What components will be checked, when and how?
- ❑ Hot work standards and procedures
  - Standard operating procedure for hot work essential.
- ❑ House keeping programs
  - Structural design must allow for cleaning underneath the belt and pulley areas.

Reducing the risk

Re-active controls (focus on minimising the consequence of fire)

- Detection
  - Ambient conditions sensors
  - Gas detectors
  - Smoke detectors
  - Flame detectors
  - Distributed Temperature Sensing (Linear cable or fibre optic)
  - Belt attendants & control room operators
- Suppression
  - Manual and/or automatic systems
  - Cover high risk areas or entire length of belt
  - Removes heat and oxygen
  - Additives can be added to reduce water requirements
- Isolation
  - Prevent exposure to toxic gases, smoke and heat
- Escape strategies
  - Escape during fire, refuge chambers essential and escape routes demarcated

Ventilation phenomena

The complex thermodynamics of a fire can have a major influence on the **ventilation system due to the phenomena of air throttling, buoyancy and rollback** (Hansen, 2011).

1) **Throttling** is caused by the increase in volume of the air as it passes through the fire.
2) **Buoyancy effect** occurs as air passes through the fire and the air density decreases.
3) **Rollback** takes place when smoke travels in the opposite direction of the airflow and occurs normally when air velocities are relatively low (<1m/s).

Engineering tools to understand ventilation phenomena

Computational fluid dynamics (CFD)

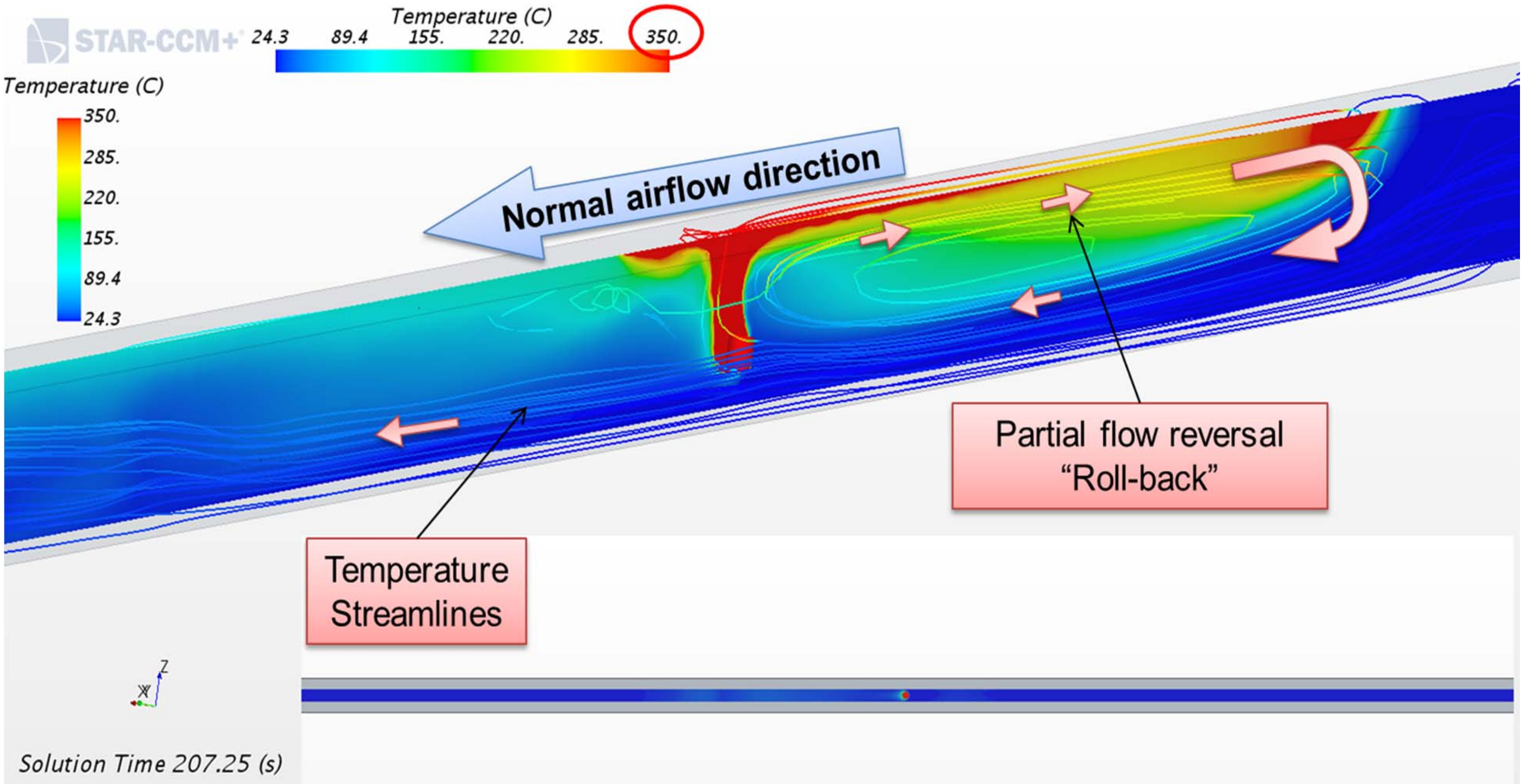
The CFD software can predict changes in primary ventilation such as rollback, throttling and full flow reversals, especially noticed where fires occur in inclined airways.

Network fire modelling software

Network fire modelling software is used to track the spread of contaminants and heat throughout the mine ventilation network.

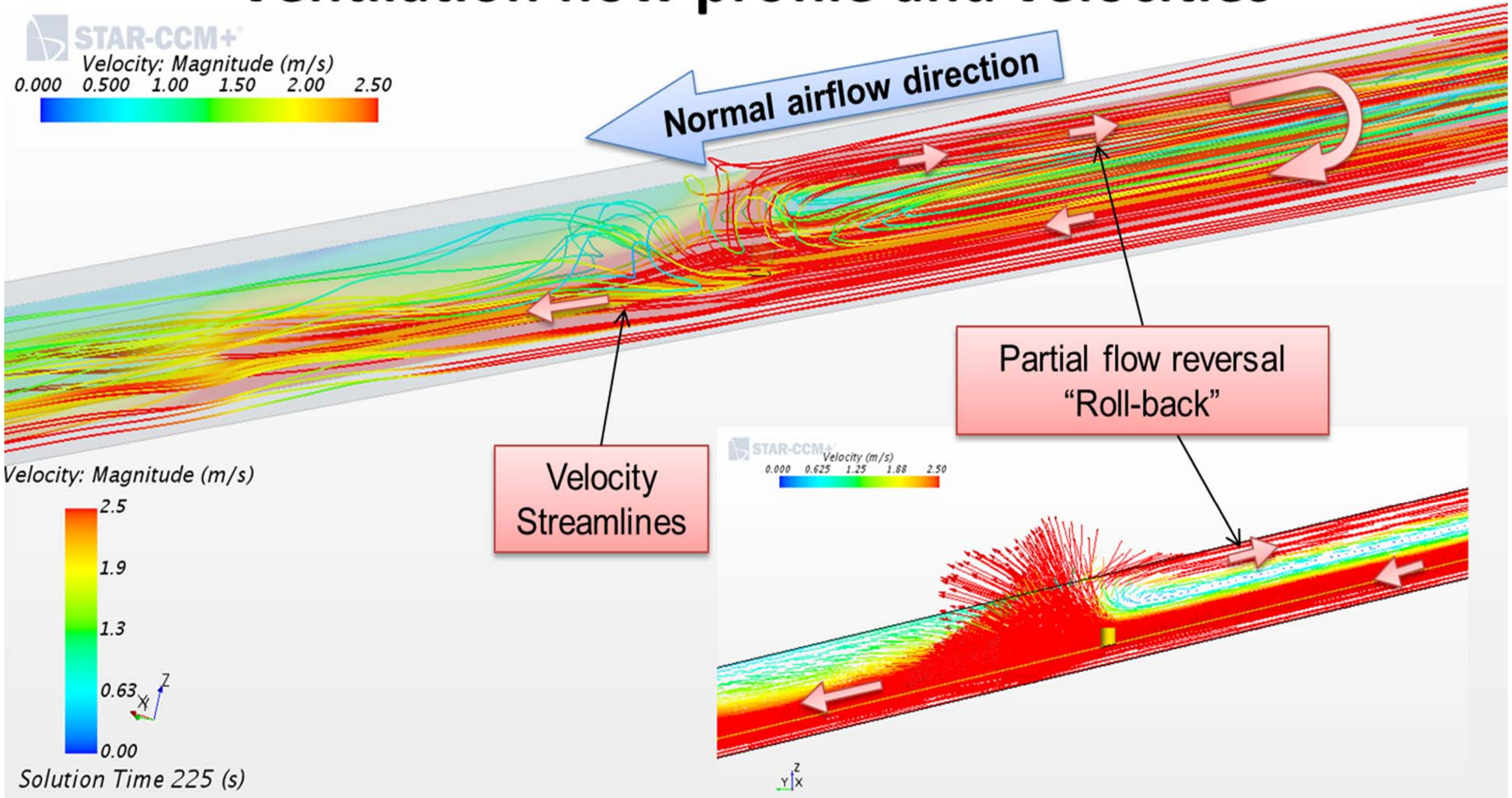
Computational fluid dynamics (CFD)

Temperature profile



Computational fluid dynamics (CFD)

Ventilation flow profile and velocities



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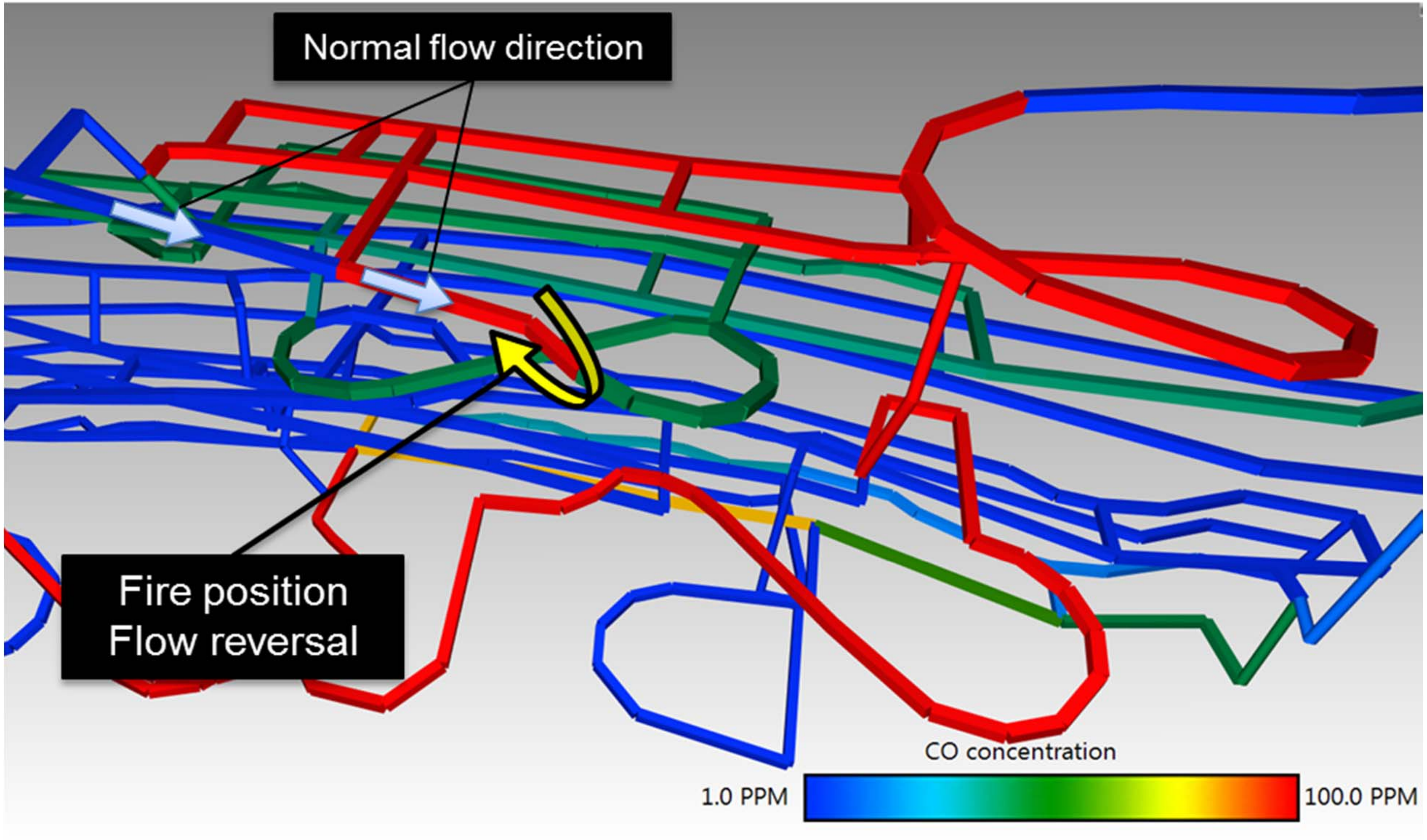
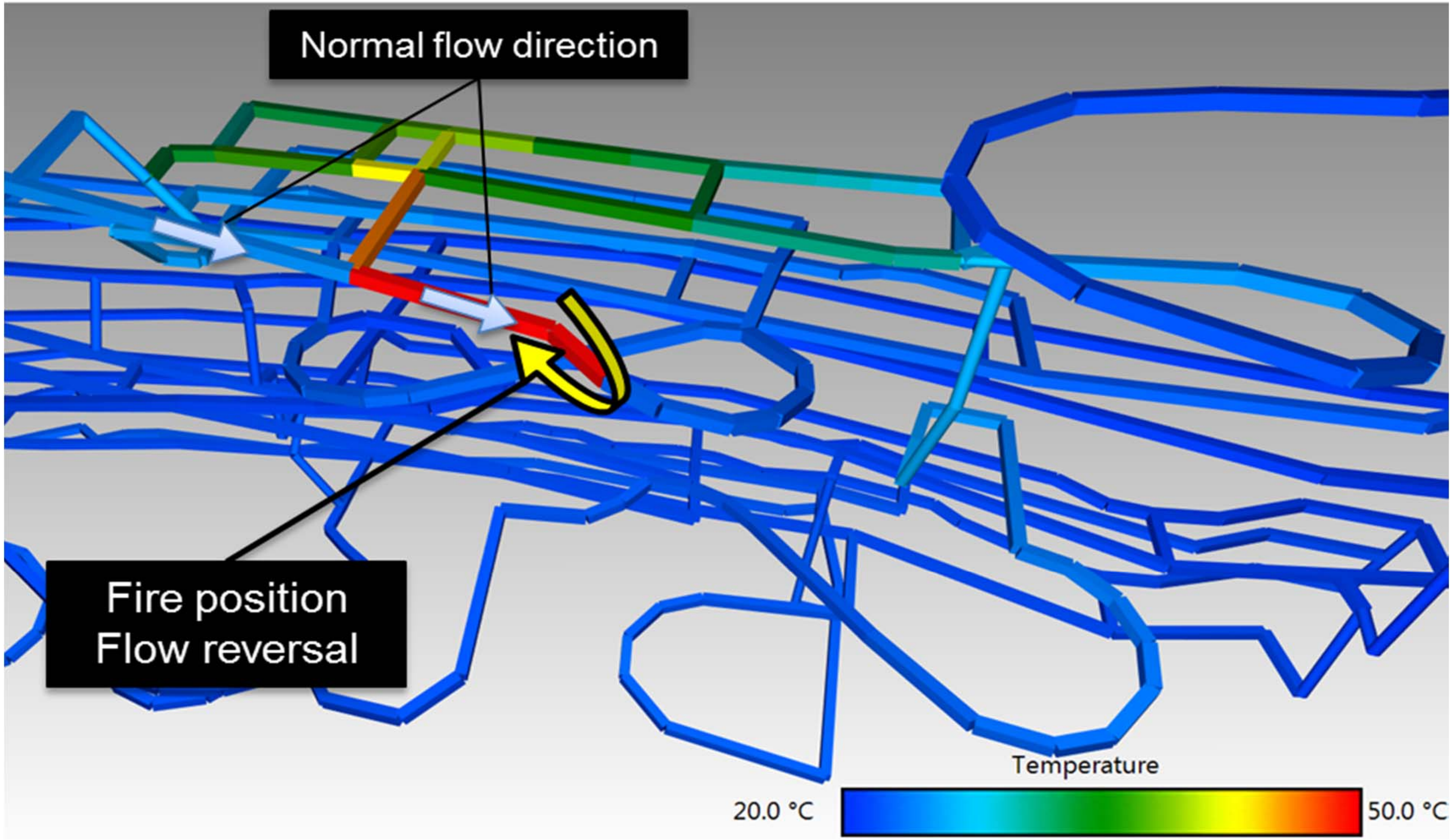
Ventilation network fire modelling



Ventilation network fire modelling



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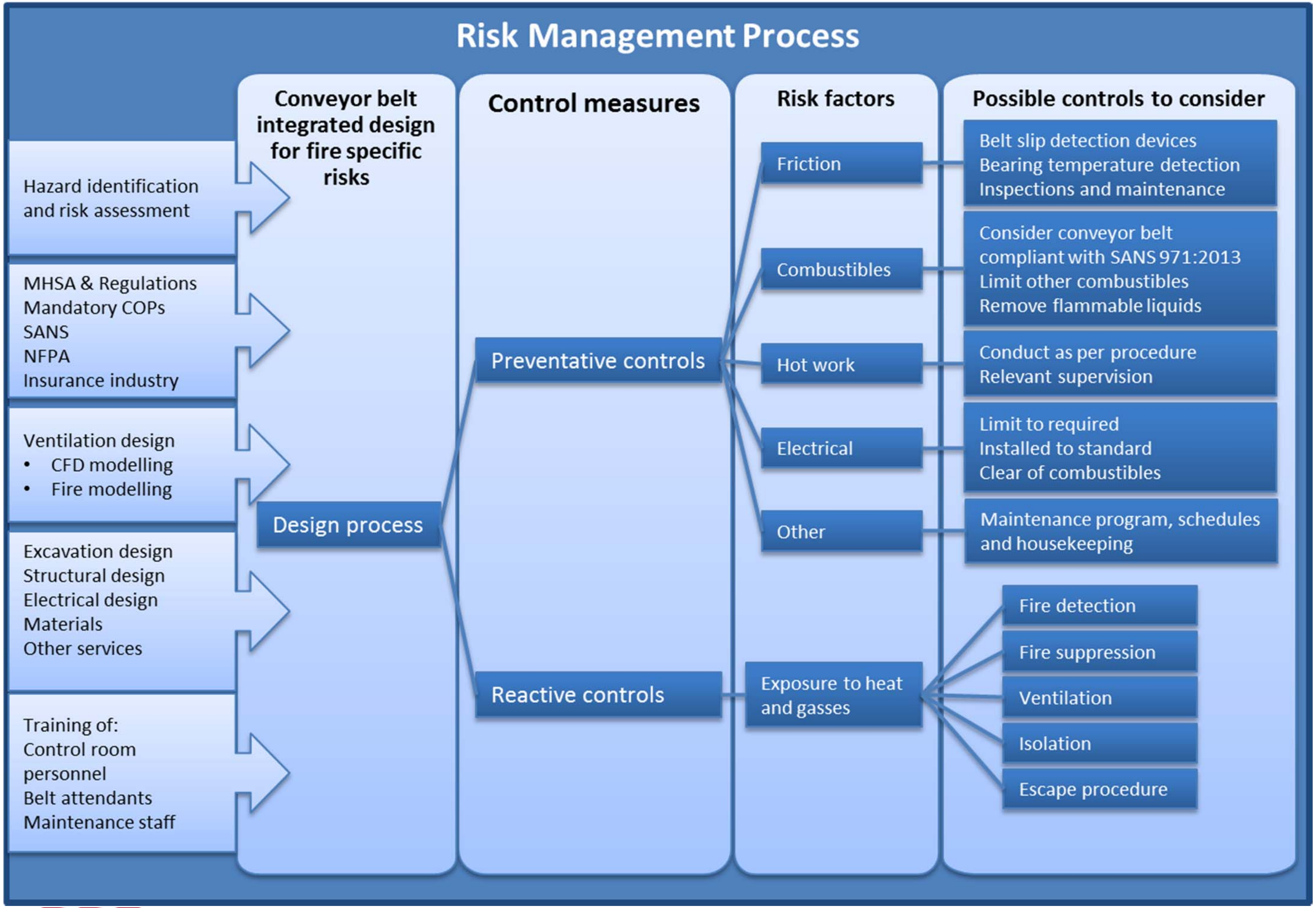
Risk Management Process
Hazard identification and risk assessment
MHSA & Regulations
Mandatory COPs
SANS
NFPA
Insurance industry
Ventilation design
• CFD modelling
• Fire modelling
Excavation design
Structural design
Electrical design
Materials
Other services
Training of:
Control room personnel
Belt attendants
Maintenance staff
Conveyor belt integrated design for fire specific risks
Design process
Control measures
Preventative controls
Reactive controls
Risk factors
Friction
Combustibles
Hot work
Electrical
Other
Exposure to heat and gasses
Possible controls to consider
Belt slip detection devices
Bearing temperature detection
Inspections and maintenance
Consider conveyor belt compliant with SANS 971:2013
Limit other combustibles
Remove flammable liquids
Conduct as per procedure
Relevant supervision
Limit to required
Installed to standard
Clear of combustibles
Maintenance program, schedules and housekeeping
Fire detection
Fire suppression
Ventilation
Isolation
Escape procedure

Conclusion

1) Conveyor belt fires can have catastrophic consequences leading to multiple fatalities, extensive infrastructure damage and substantial financial losses
2) Reducing the risk of conveyor belt fires is highly complex with many aspects to consider
3) Fire engineering must consider that many of these aspects is interdependent
4) Software tools can provide vital information about ventilation system changes during a fire scenarios

The end