

Spontaneous Combustion Prediction and Remediation Techniques

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Outline of presentation

- Introduction
- Statement of problem
- Hypothesis
- Research approach
- Pressure balancing
- Conclusions

Introduction

- Spontaneous combustion (Sponcom) is a process in which certain material can ignite as a result of internal heat which arise spontaneously.
- In the process reaction generates heat faster than it can be removed from ventilation.
- Sponcom accounts for 15% of total fire recorded in U.S. since 1990.

Statement of problem

- Coal has an inherent tendency to combust in the presence of oxygen.
- Barometric pressure changes cause ingress and egress of air in gob area.
- Ingress of air can cause Sponcom whereas egress may lead to methane flooding in working area.

Fire due to sponcom



Fire in an opencast mine



Fire raging from the cracks

Fire due to sponcom



Subsidence and crack formation due to fire.



Fire near the mine camp

Hypothesis

- Pressure balancing system is seldom used in U.S.
- Crucial parameters related to pressure balancing are not well understood.
- Factors governing implementation of pressure balancing are not well known in the US coal mines.

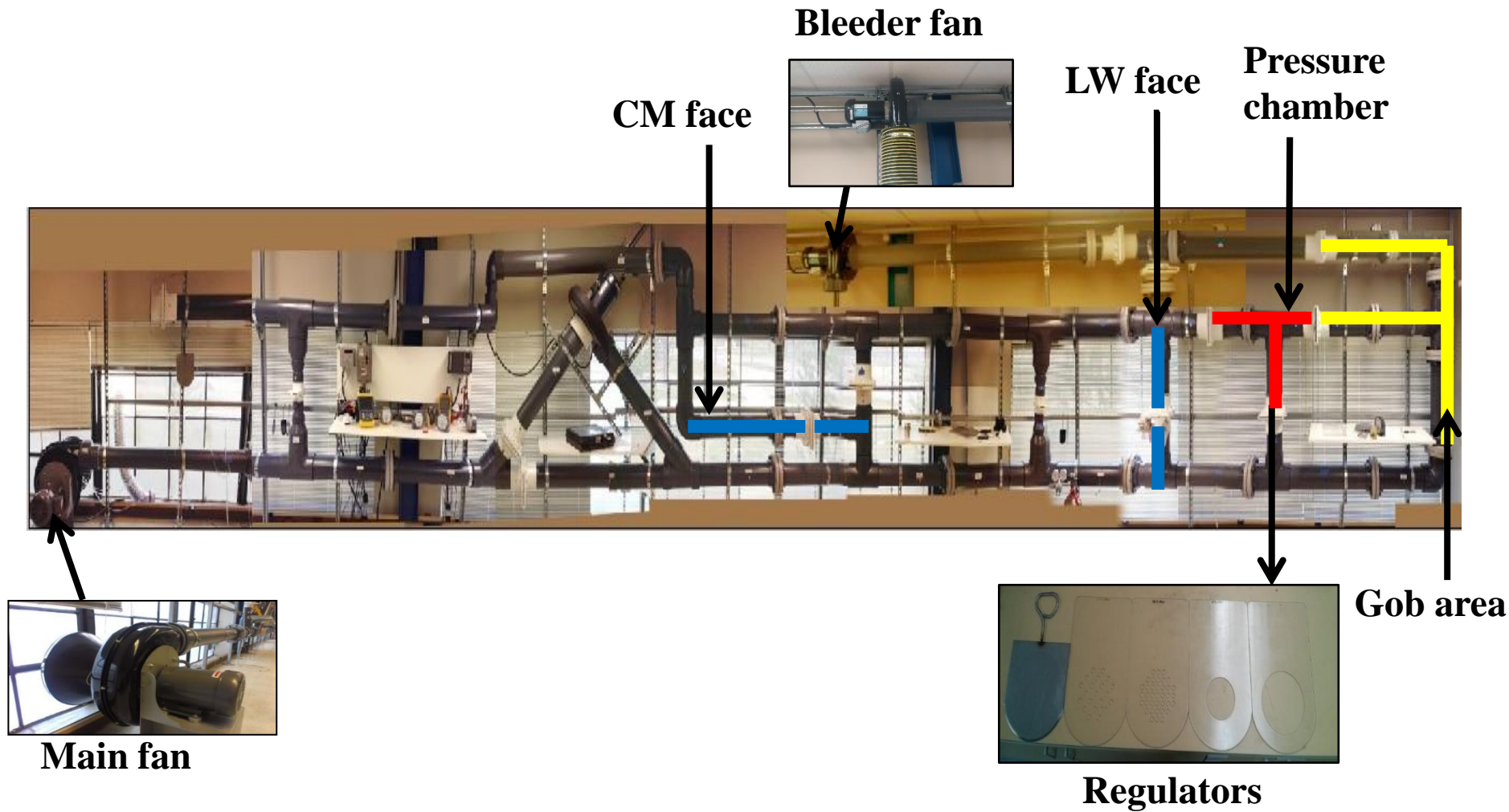
Remediation techniques

- Placing ventilation controls to reduce pressure differentials across gob area.
- Sealing mined out areas to preclude airflow towards the gob area.
- Inertization: Flooding gob area with inert gas to render the atmosphere inert.
- Pressure balancing: Equalizing pressure between the workings and worked out areas to preclude chances of sponcom.

Types of pressure balancing

- Passive pressure balancing
 - Balancing using regulators and fans.
 - Airflow of mines can be used for balancing pressure.
- Active pressure balancing
 - Used when passive pressure not feasible or possible.
 - Requires external source of gas injection.
- Automatic pressure balancing
 - Balancing pressure using continuous monitoring system automatically.

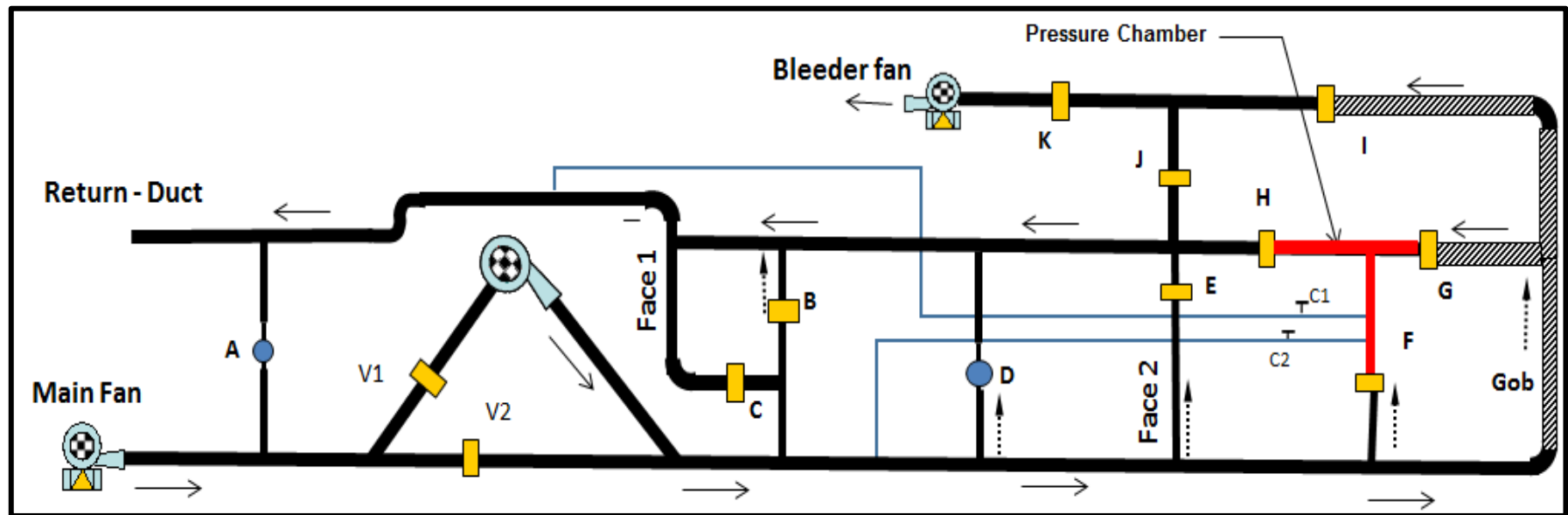
University of Utah lab model



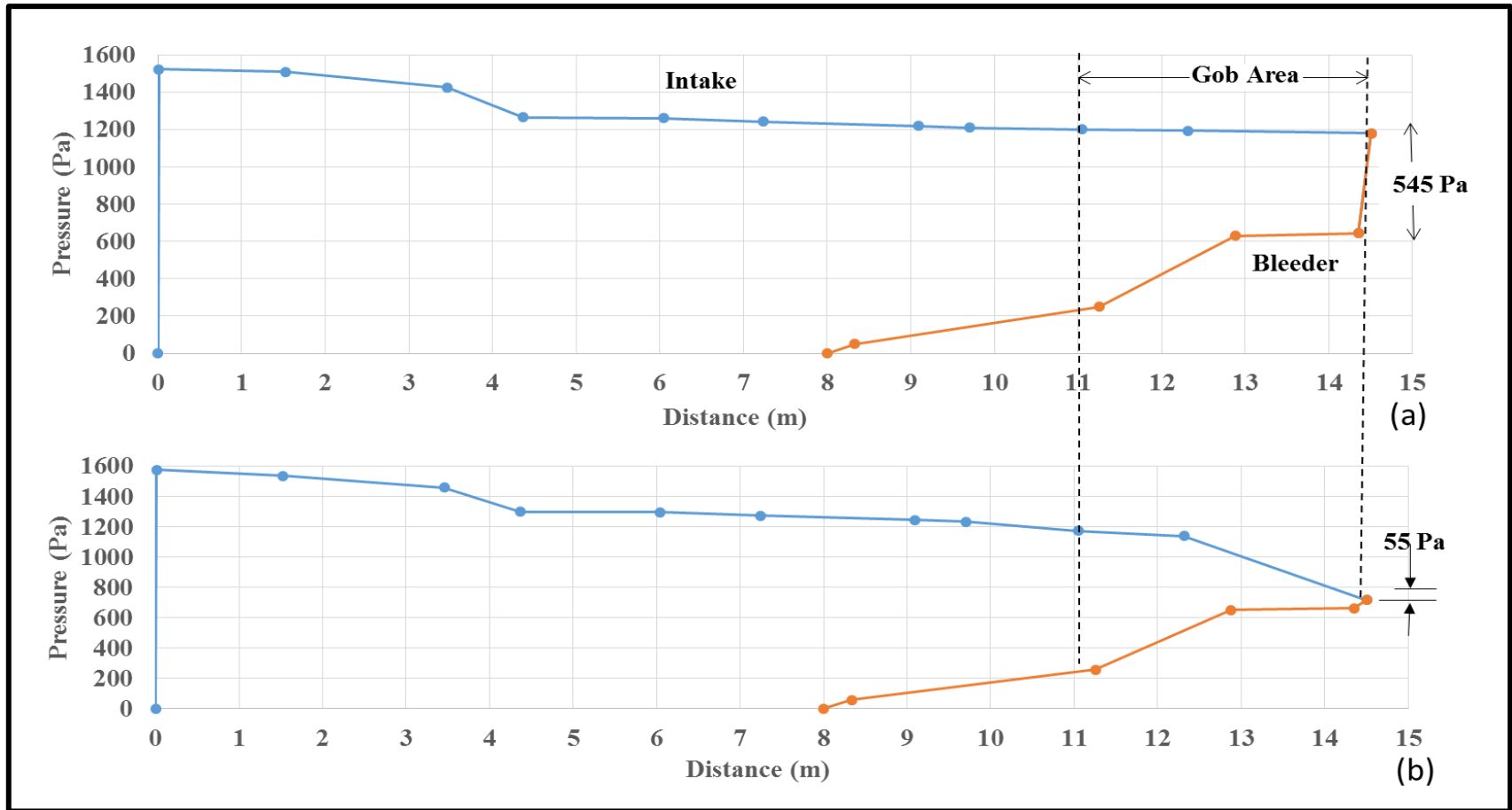
Passive pressure balancing

- Pressure chamber was established using three fully blocked gate valves at F,G and H.
- Chamber was connected to intake and return ducts using plastic tubes. Control valves were used to control the flow.
- Once steady state condition was established, valves were opened.
- Pressure across the gob area reduced using existing airflow of the model.

Initial setting at the model



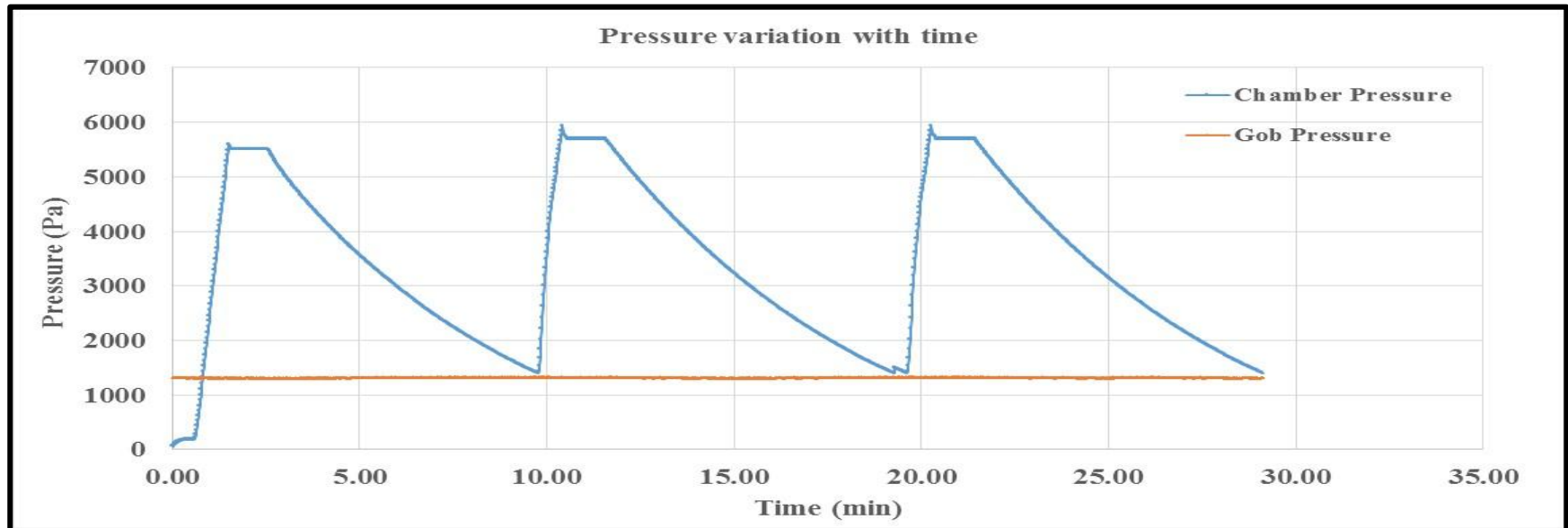
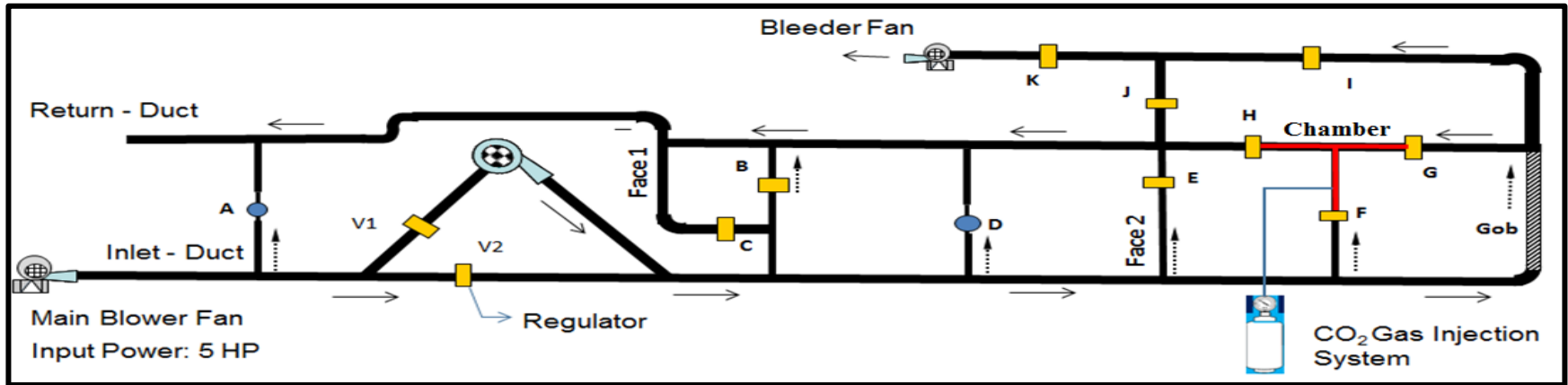
Pressure profile at lab model



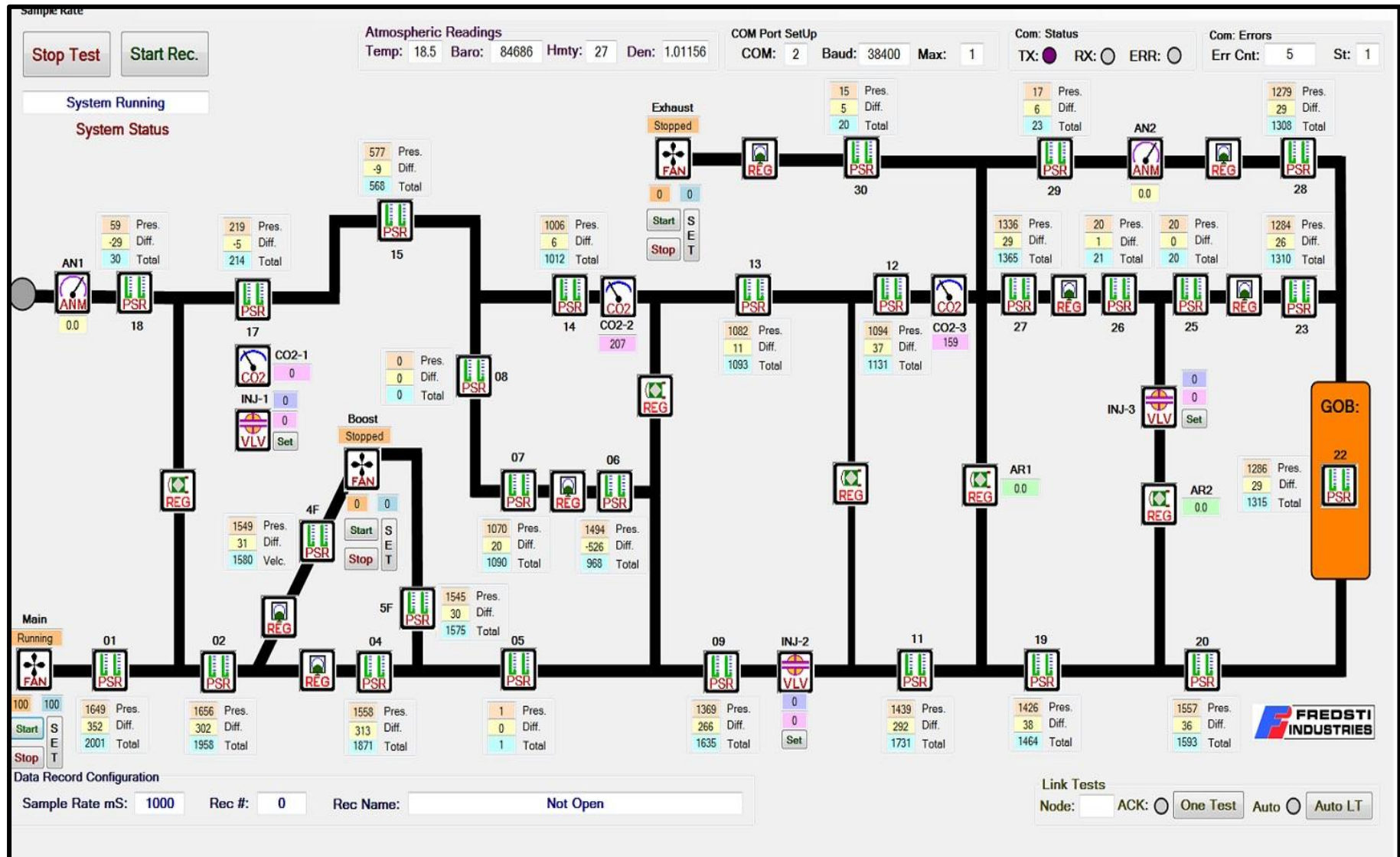
Active pressure balancing

- Pressure chamber was established using three fully blocked gate valves at F,G and H.
- Chamber connected to external source of injection using tubing.
- Carbon-dioxide cylinder is used as pressure source.
- Pressure build-up and decay were recorded and plotted with pressure at the gob.

Pressure profile at lab model



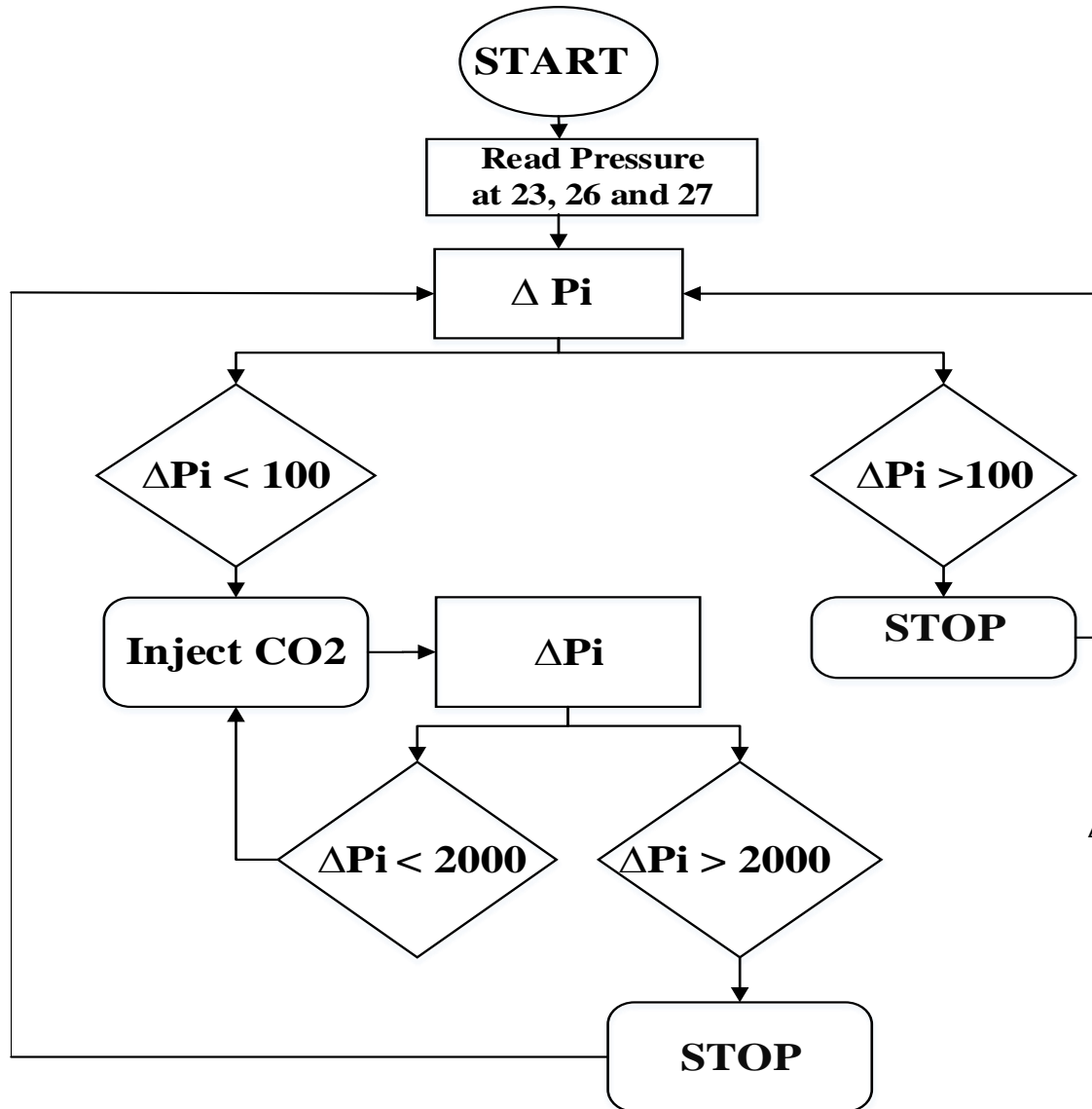
Continuous monitoring system



Automatic pressure balancing

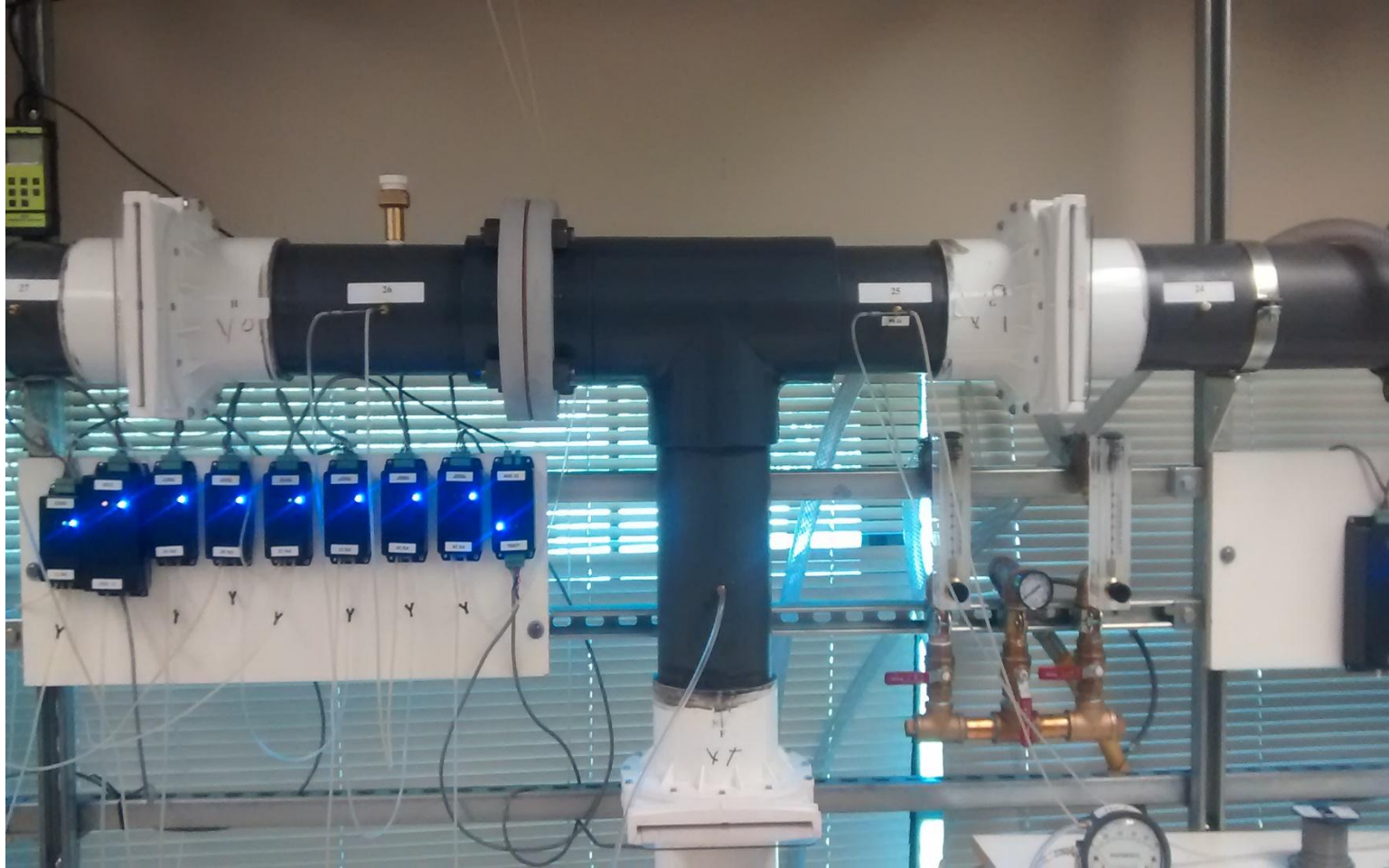
- Pressure balancing is performed by measuring pressure differentials and pressurizing the chamber automatically.
- This is achieved by running a computer program
- Data to be used in the code are obtained from pressure transducers.
- Pressure is balanced when chamber pressure is less than either the gob or mine side pressure.

Automatic pressure balancing



$$\Delta P_i = P_s_{23-26} \text{ and } 27-26$$

Chamber with transducers



Automatic pressure balancing

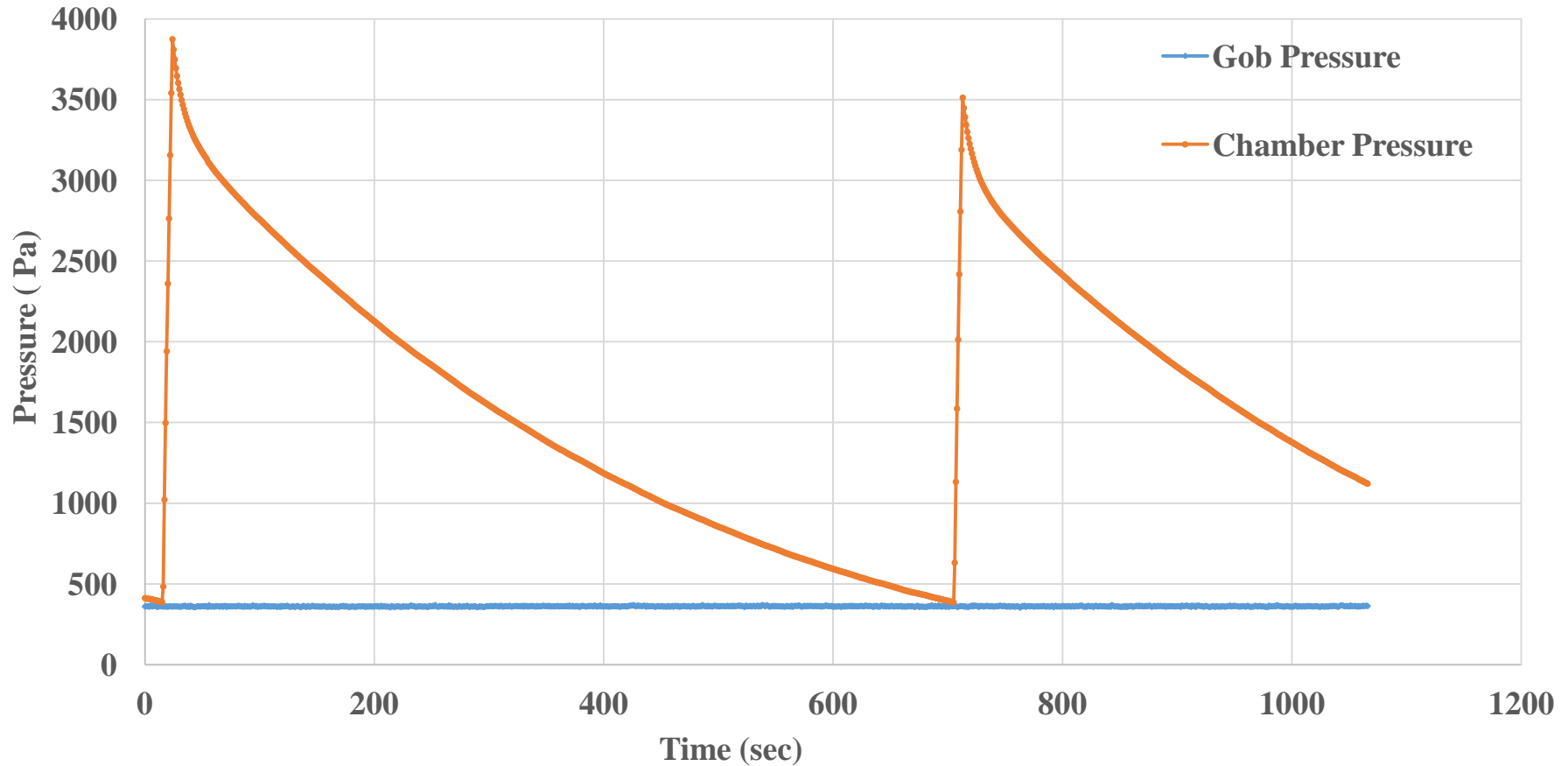
- Gage pressures are recorded at station 23, 26 and 27
- Readings are fed into the control program, and pressure differentials are evaluated.
- In case the pressure difference across the gob is less than 100 Pa, CO₂ is injected.
- Injection continues till the pressure differential is 2000 Pa.

Automatic pressure balancing

- Passive balancing is limited by pressure and flowrate at intake and return airways.
- Pressure changes in gob due to changes in barometric pressure are difficult to handle.
- Automatic pressure balancing uses a control program and an external pressure source to balance pressure differentials automatically.
- It can react to changes of barometric pressure in lab.

Automatic pressure balancing

Pressure variation with time



Implementation at mines

- Pressure chamber should be established by erecting stoppings parallel to seals.
- Depending upon barometric pressure changes at the location of mine, method of balancing should be decided.
- Rate at which pressure differential decays can be calculated and used to arrive at inert gas requirements in case of active and automatic balancing.

Conclusions

- Pressure balancing is an effective technique to reduce pressure differentials across the gob and prevent spontaneous combustion.
- Passive pressure balancing is preferable if feasible.
- Balancing can be achieved using automatic pressure balancing. Barometric pressure variation can be managed.
- Condition of seal and stoppings is crucial in respect of balancing the pressure.

Thank You!

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The views, opinions and recommendations expressed herein are solely those of the authors and do not imply any endorsement by the ALPHA FOUNDATION, its Directors and staff.

Questions?