JMU.002.001.0001

Methane gas explosions

JMU.002.001.0002

Methane characteristics

Methane is:

- A colourless, odourless hydrocarbon gas which is less dense than air
- Naturally occurring in coal seams
- Flammable and explosive when mixed with air at concentrations between 5-15%

JMU.002.001.0003

Causes of methane ignition

When methane is present between its explosive limits, it can ignite when:

1. Heated to its autoignition temperature of 540°C
2. It comes in contact with a surface at or above 540°C
3. There is an external ignition source (such as a flame or a spark)

JMU.002.001.0004

What happens when methane ignites?

- A flame front expands outwards through the surrounding gas-air mixture for as long as there is fuel in the surrounding atmosphere

- The flame front will initially have a spherical appearance, until it becomes turbulent and/or meets obstacles in its path

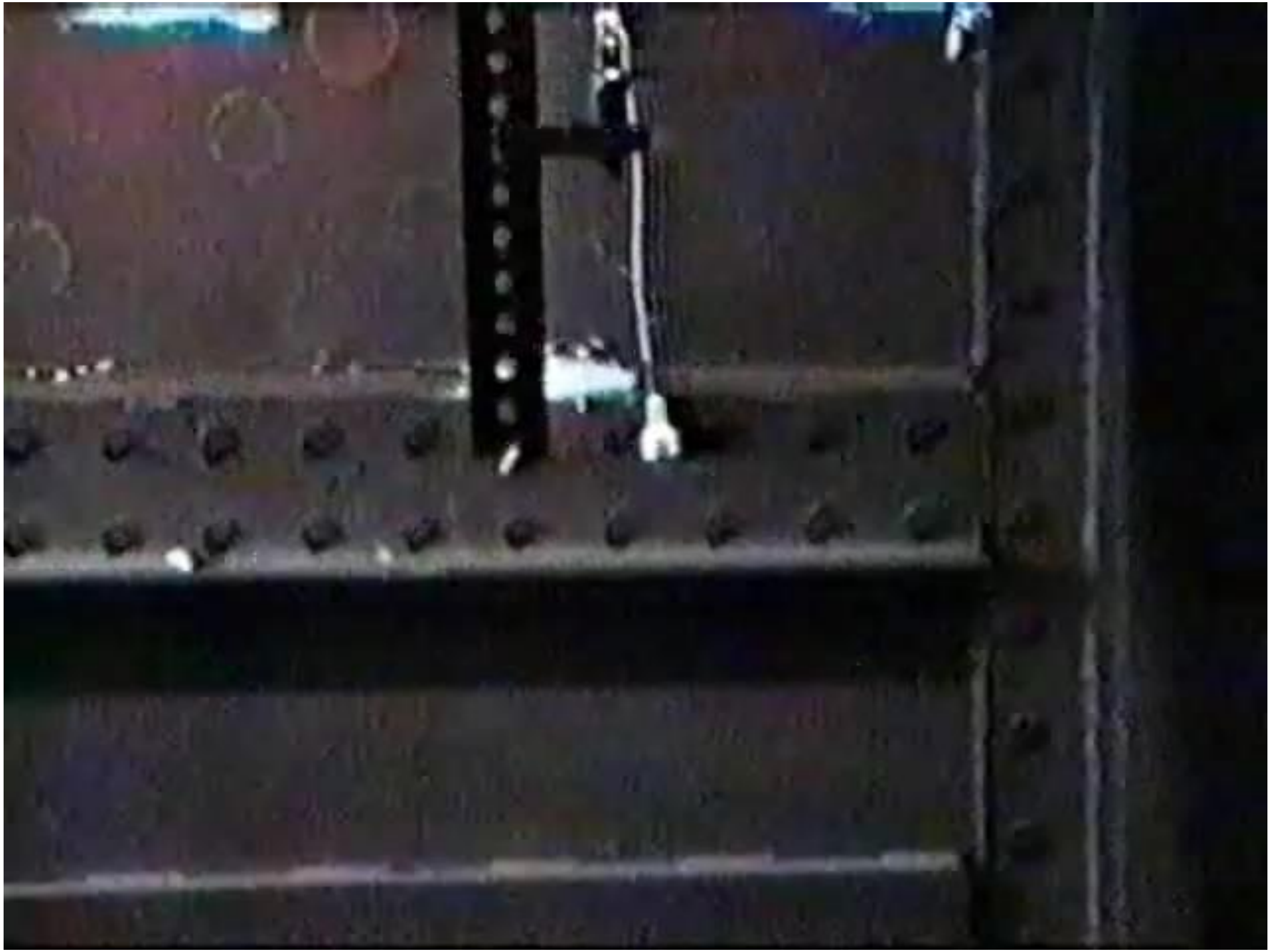
- There are two types of methane explosions: deflagration and detonation

JMU.002.001.0005

Flame speed and shape

- The flame front will travel through the air at 3.5m/s for the first fraction of a second to a second
- After that time, the flame front becomes turbulent because it is drawing in air and will accelerate quickly
- The turbulence and interference from surrounding objects and structures can cause the flame front to travel more rapidly in some directions than others

JMU.002.001.0006



JMU.002.001.0007

Associated pressure wave

- As the gas burns and generates heat, the air immediately adjacent to the flame front is heated rapidly and becomes pressurised

- This forms a pressure wave which moves ahead of the flame front

- The amount of heat (and therefore the magnitude of the pressure wave) is directly related to the quantity of gas reacting with the oxygen in the air

JMU.002.001.0008

Associated pressure wave

- The intensity of the pressure wave is increased when the burning velocity increases

- In the open, a deflagration may not cause a pressure wave

- In an enclosed or semi-enclosed space, a deflagration causes a pressure wave which can displace objects in its direction of travel (like a wind gust)

JMU.002.001.0009

Variations of methane explosions

- Hybrid explosion
- Multiple or cascade explosion
- Combination hybrid/multiple explosion

JMU.002.001.0010

Fire damage

- The flame front following immediately behind the pressure wave can produce:
  - Superficial heat damage
  - More significant radiant heat which may include ignition of combustibles and significant burns
- The degree of damage caused by the flame front depends on the concentration of gas and rate of rise of the associated pressure

JMU.002.001.0011

Consideration of the events of 6 May 2020

JMU.002.001.0012

The first pressure wave

- Two possibilities:

  1. Mechanical air compression, likely a result of strata collapse in the goaf
  2. Deflagration in the goaf as a result of heating or ignition in the goaf

- In either case, methane would have been pushed from the goaf towards, or onto, the longwall face

JMU.002.001.0013

Limits to understanding the possible deflagration in the goaf

- The size and shape of the goaf is unknown, as is the location of the rocks and voids
- It is not possible to know the speed or direction of travel, within the goaf, of any flame front that originated in the goaf

JMU.002.001.0014

Multiple/cascade explosions?

- The first and second pressure waves are unlikely to be multiple/cascade explosions because the time lag between them was too great

- A flame front originating from approximately 30-40 metres back in the goaf would travel to the longwall in less time than 15 seconds (more like 1-2 seconds)

JMU.002.001.0015

The flame front and associated pressure wave

- The second pressure wave and associated flame front has all the characteristics of a deflagration originating on or near to the longwall face

- If there was coal combustion in the goaf behind the shields, this could be the source of a hot or glowing surface (or small flame) capable of igniting the methane-air mixture in the face via the exposed space between the shields

- It is not possible to say whether that explosion was a methane-air deflagration, a coal dust-air ignition or a hybrid event

JMU.002.001.0016

The flame front and associated pressure wave

- The flame front would have stopped when there was no longer sufficient fuel in the atmosphere. The pressure wave would have continued

- The ignition source has not been determined, but static electricity discharge can be ruled out because the humidity was too great

- Possible ignition sources are spontaneous combustion, friction spark caused by rock on metal, or an arc from compromised electrical cables or equipment

JMU.002.001.0017

Descriptions of the pressure waves

- The descriptions of the intensity and duration of the pressure waves are consistent with a methane deflagration

JMU.002.001.0018

JMU.002.001.0019

Descriptions of the flame front

- The descriptions of the intensity, duration and colour of the flame front are consistent with a methane deflagration

JMU.002.001.0020

Fire damage and physical injuries

- The burns to the workers’ clothing, and the workers themselves, are consistent with exposure to a high-energy deflagration flame front

- Some of the burns are too severe to be explained by the flame front alone (whether gas-air, coal dust-air or hybrid gas). Rather, clothing and personal equipment likely continued to burn after the flame front passed

JMU.002.001.0021

"Suck back" effect observed by some workers

- The suck back effect described by some of the workers could be a consequence of a negative pressure wave caused by replacement of the air displaced by the pressure wave