

Methane gas explosions

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%

Causes of methane ignition

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

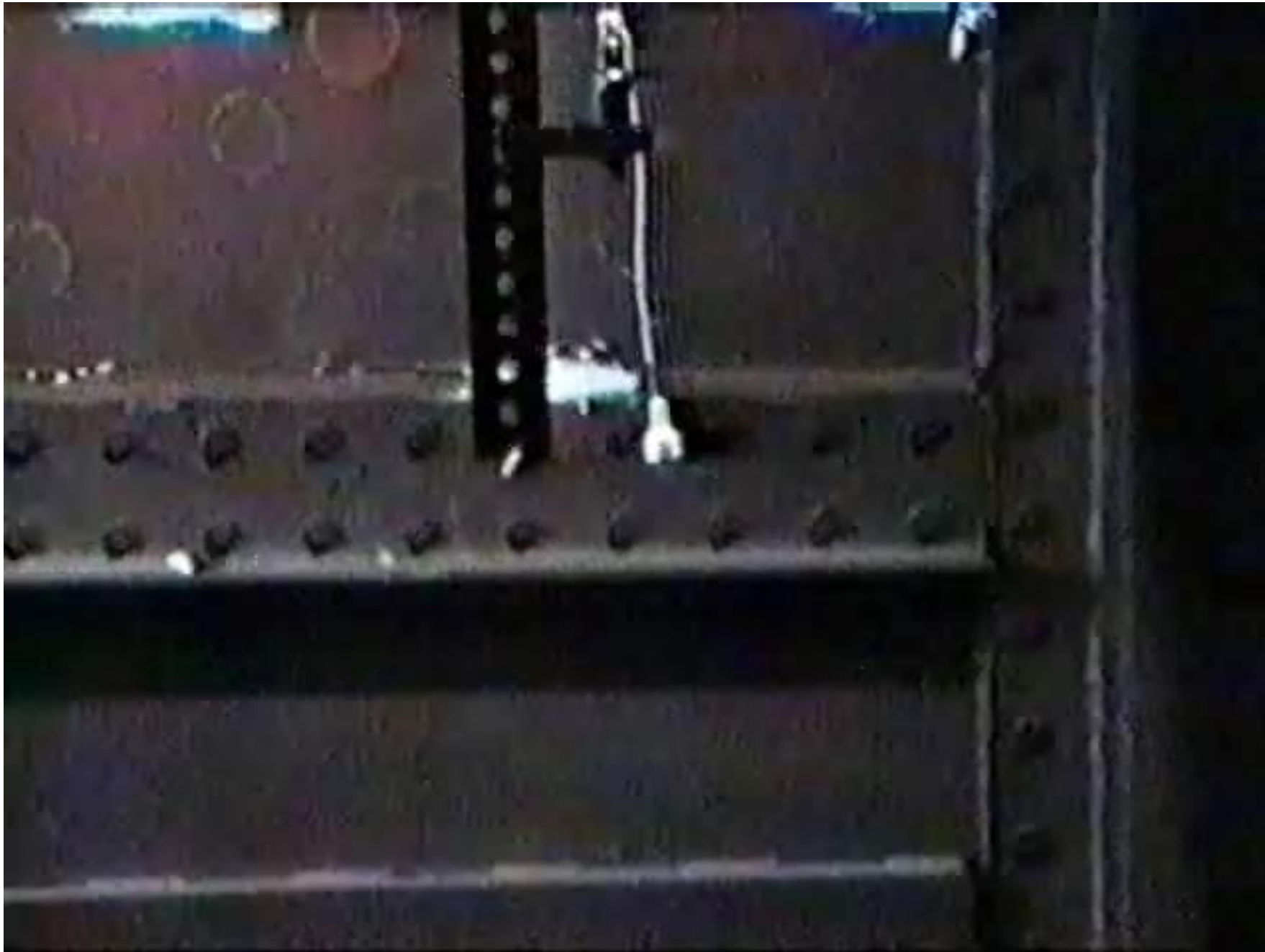
1. Heated to its autoignition temperature of 540°C
2. It comes in contact with a surface at or above 540°C
3. There is an external ignition source (such as a flame or a spark)

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

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



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

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)

Variations of methane explosions

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

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

Consideration of the events of 6 May 2020

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

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

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)

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

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

Descriptions of the pressure waves

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



 FIRE
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Descriptions of the flame front

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

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

“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